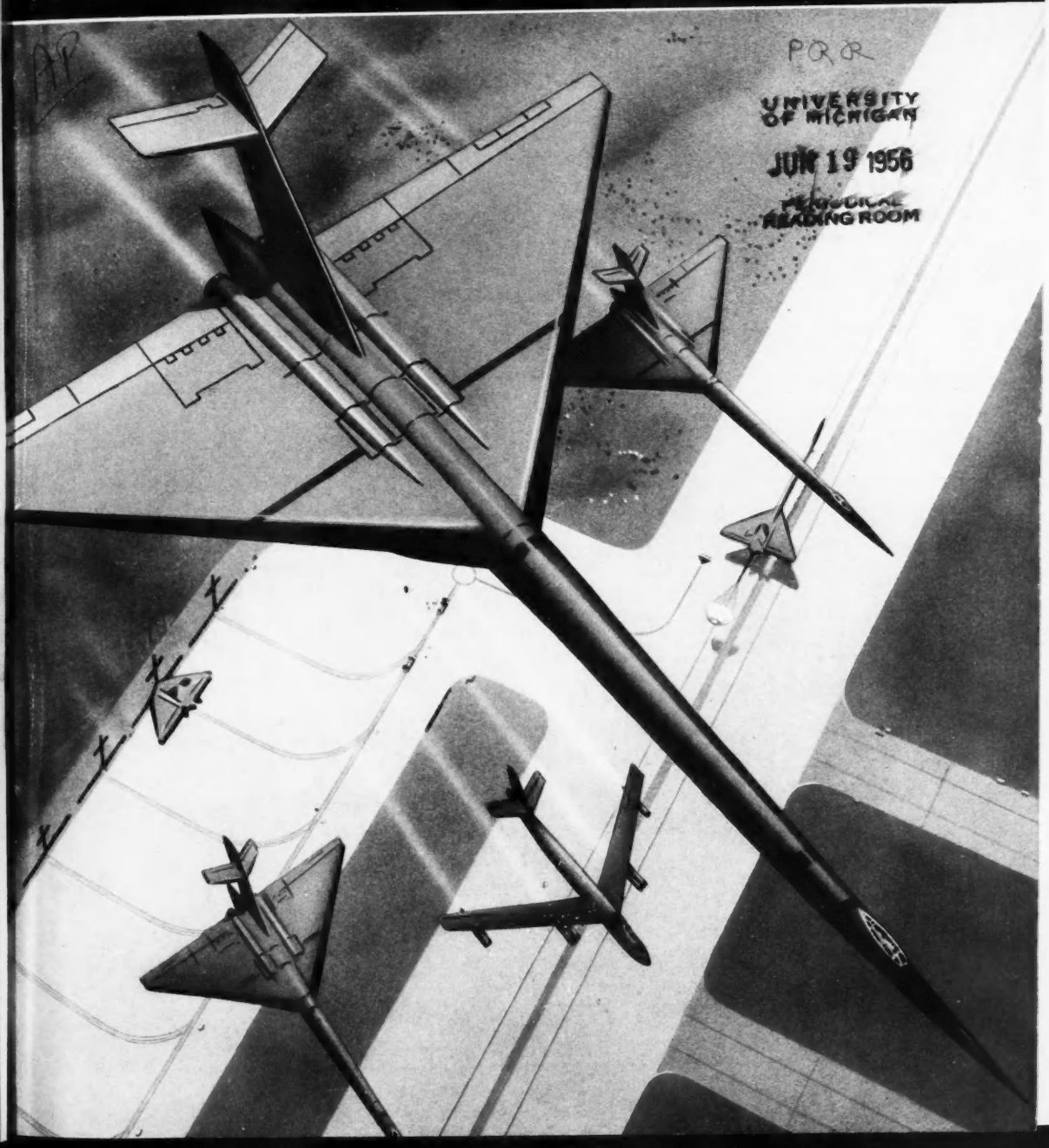
DISCOVERY

JUNE 1956 2/6



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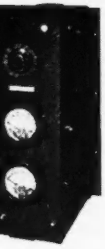

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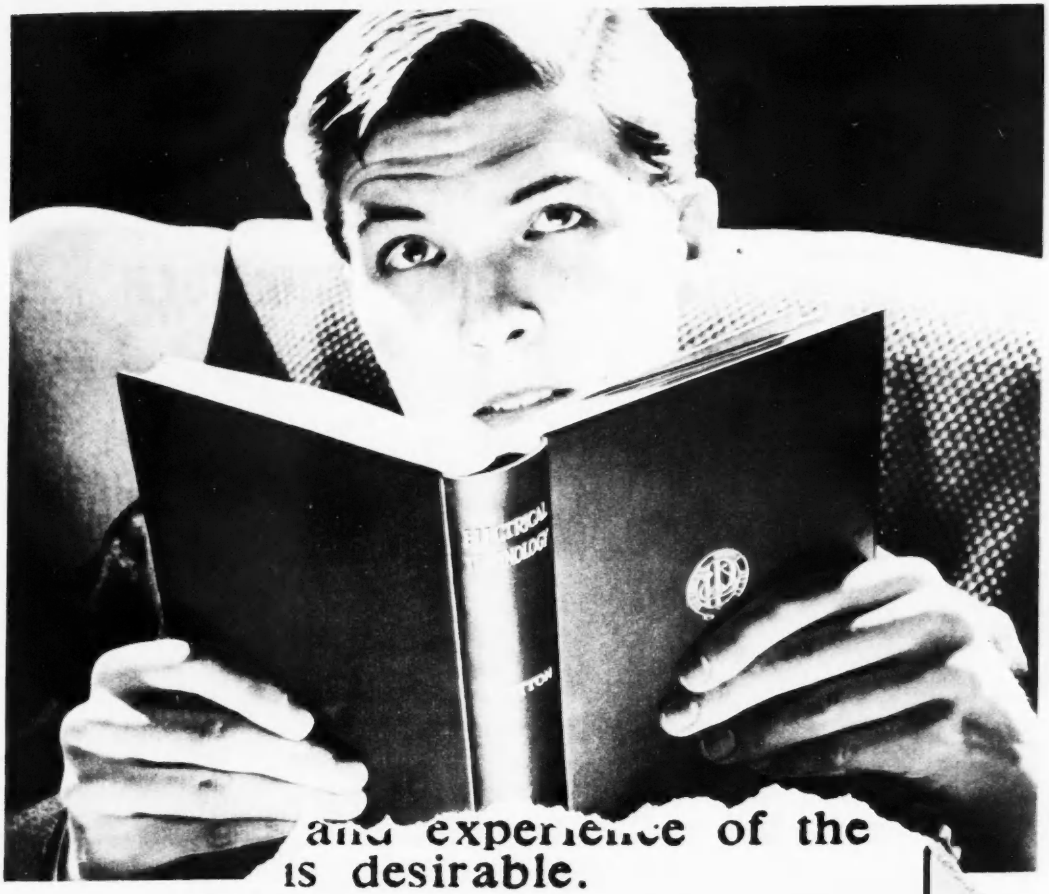

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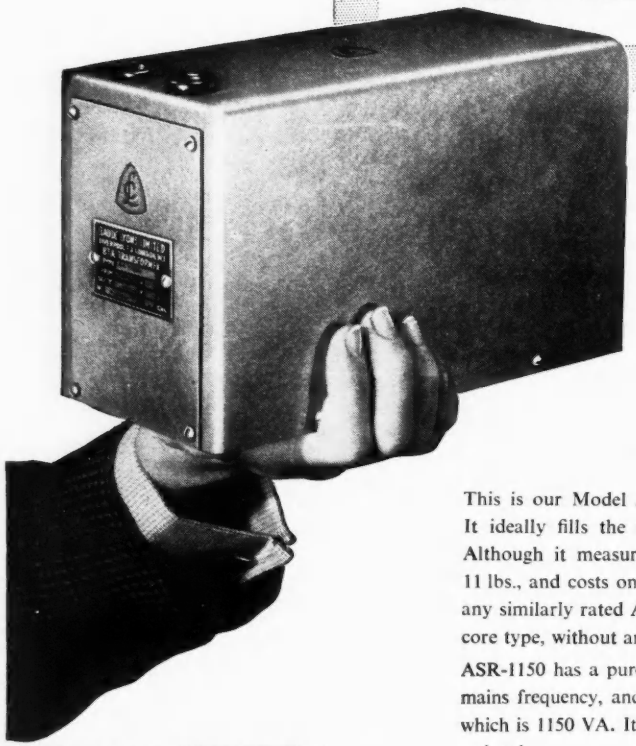

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DISCOVERY

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SUBSCRIPTION, DISTRIBUTION AND BUSINESS COMMUNICATIONS TO: Jarrold & Sons Ltd., Norwich. Norwich 25261
ADVERTISEMENT OFFICE: Aldridge Press Ltd., 27 Chancery Lane, W.C.2. HOLborn 8655

JUNE 1956 VOLUME XVII NUMBER 6

CONTENTS

COVER PICTURE: Rolls-Royce in Great Britain and a number of aircraft firms in the United States are at work on designs for an atomic aeroplane which would be able to travel enormous distances on power from a lump of uranium the size of a man's fist. The cover shows three such planes with an American B-47 jet for comparison. The fourth atomic plane is using a drag parachute, and a fifth is just disappearing into its protective hangar.

SOLAR FLARE OF FEBRUARY 23, 1956

A note on this subject appeared in the May issue of DISCOVERY, and further information has arrived later from the Enrico Fermi Institute for Nuclear Studies, the University of Chicago. A preliminary report with the title "Temporary Increase of Cosmic Ray Intensity following the Solar Flare of February 23, 1956", gives the results that were obtained from the nucleonic component detector E-3 at Chicago and from a high-altitude measurement of nucleonic component intensity over Chicago during the event. The onset of the increase took place at 3h 50m U.T., and in 8 minutes it had attained ten times preflare intensity, a maximum factor of 24 being reached 20 minutes after the onset. At 5h 20m U.T. the intensity had dropped to ten times the level which preceded the flare, but the preflare level was not reached before a period of more than 18 hours. The evidence showed conclusively that this event was the largest increase of cosmic ray intensity known to occur in association with flares. The following are some tentative conclusions:

(1) The production of cosmic ray particles was by the Sun, and no hypothesis of focusing, terrestrial effects, or particle storage, for example, in magnetised clouds, explains the observational results.

(2) For the first time there was the possibility of measuring with considerable precision the time sequence of the optical and radio noise onsets, the ultra-violet outbursts, and the onset of the cosmic ray intensity increase. The upper limit for the delay between the flare and cosmic ray onset is 19 ± 2 minutes, and the time delay between maximum flare intensity and cosmic ray onset is 8 minutes. The small range of delay times and the sharp rise to maximum intensity suggest that the onset must have been produced by particles traversing orbits relatively free from scattering or diffusion, in other words, along relatively simple trajectories during the first hour of the event.

(3) The fact that the solar processes apparently ceased within 2 hours after the onset suggests that particles scattered back to the Earth from many other directions in the solar system were the cause of the continuing incident radiation which produced the "tail" of the intensity curve.

(4) It is shown in Fig. 2 that balloon flight 2 reached the transition maximum for the secondary neutral component at 14h 26m U.T. where the intensity was 180%

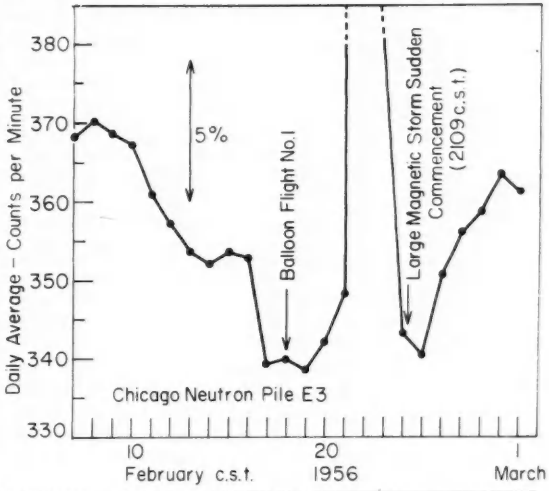


FIG. 1 (*above right*). Daily average of nucleonic component intensity as a function of time preceding and following the solar flare event as measured at Chicago station E-3. Balloon flight No. 1 was a neutron intensity monitor.

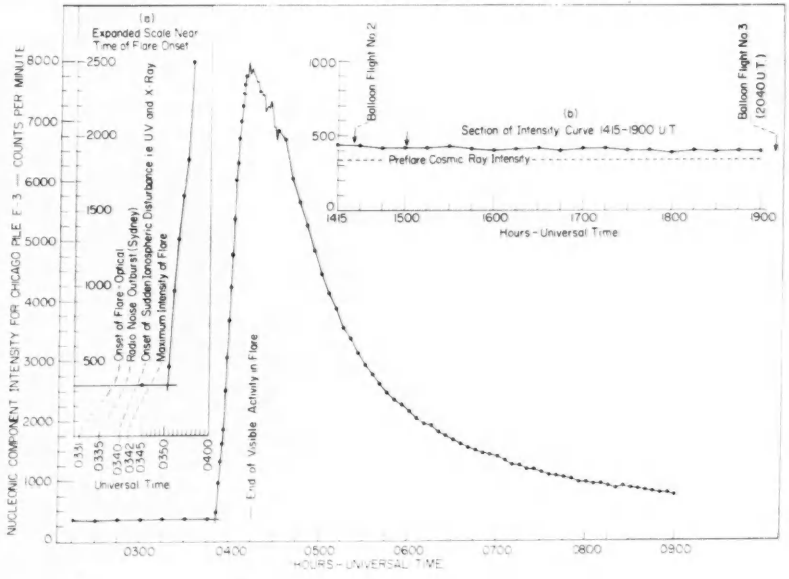


FIG. 2 (*right*). Nucleonic component intensity as a function of time as measured at Chicago station E-3

(*a*). Onset of intensity increase on expanded scale.

(*b*). Period of flare increase when balloon flights (arrows) were undertaken. (No. 2 neutron intensity monitor; No. 3 photographic emulsion).

above normal. At that time the sea level intensity was 26% above the normal, and the changes in the slope of the altitude curve below the transition maximum prove that the flare particles were of lower mean energy than the average cosmic radiation over Chicago. It is pointed out that (3) argues strongly for isotropic incidence of these particles at the time of flight number 2, which explains why the flare particle energy spectrum at that time was significantly steeper than the normal spectrum.

(5) As shown in Fig. 1, the flare event occurred about 6 days after the total isotropic cosmic radiation had undergone a sharp intensity decrease which persisted beyond the time of the flare. This superposition of events is regarded as fortunate because it permits the use of flare particles as probes to define the limits on particle scattering by clouds of ions carrying magnetic fields in the nearby interplanetary volume.

The other paper by the same authors, under the title "Solar Flare Cosmic Ray Particles in Excess of 15 Bev. Energy", gives a report of the preliminary results of measurements at the geomagnetic equator, i.e. the nucleonic component intensity monitor at Huancayo, Peru. The detector measures the integrated nucleonic component produced by particles arriving mainly from the vertical direction.

Assuming the time for the onset of the cosmic ray increases is as given at the beginning of this summary, the increase above preflare intensity reached approximately 60%, and as this took place about local time 24h this equatorial increase was obviously produced by charged particles. Calculations of orbits between the Sun and the Earth, in equatorial zones, show that the mean energy of the incoming particles was in excess of 20 Bev., on the assumption that the particles were protons. From the energy dependence of the flare particle spectrum it follows that some of these particles in the vicinity of the flare were accelerated to energies probably in excess of 30–40 Bev. The limits previously observed for this kind of phenomenon were less than 10 Bev.

The authors are Peter Meyer and J. A. Simpson and assistance was rendered by the Office of Scientific Research and the Geophysics Research Directorate, Air Force, Cambridge Research Centre, Air Research and Development Command, U.S. Air Force.

BREAD AND BUTTER COURSES

It is difficult on the face of it to believe that any problem of national magnitude may be solved by providing sandwich courses at technical colleges, yet that is the impression left by reading the White Paper on Technical Education.

British industry is falling behind in the international race because Britain is not producing enough technologists, technicians, and craftsmen. The universities now turn out some 2300 technologists a year, and the technical colleges about twice that number. The White Paper proposes as soon as possible to increase this output of the advanced courses at technical colleges by 50%, and suggests that much of this training will take the form of sandwich courses—four- or five-year courses spent alternately, say in six-monthly periods, at college and in industry itself.

Responsibility for this expansion has been laid primarily upon twenty-four technical colleges selected to become advanced technical colleges and already encouraged by grants at specially high rates for advanced work. West Ham Technical College, one of the twenty-four, has been quick off the mark, and details have reached us of their proposed five-year sandwich course in chemical engineering: regarding it as a prototype, we thought it worth further investigation.

The course is aimed at the new Technological Award announced in the White Paper—an award at university degree level to be administered by an independent body recently set up for the purpose. The first fifteen to twenty students will begin work in September: the college could take forty if they were forthcoming, but that issue lies with industry and with the schools. Certain influential firms, such as Unilever, are already co-operating and will provide the first intake. Whether others follow suit, particularly the middle-sized and smaller firms, will no doubt be a matter of money's worth, depending on the value of the training provided by the college, the extent of financial assistance obtainable by individual students from Local Education Authority funds, and the estimated chances of holding on to an employee once he has completed his course.

The West Ham course is "works-based", that is to say all students will be paid and paid for by industrial firms. The Ministry recognises, however, that it may also be necessary to set up college-based sandwich courses for students who go to them straight from school. Here, and in cases where industries would sponsor suitable students if they could find them, the co-operation of the schools is essential. Many headmasters do not at present seem favourably disposed. No doubt the entry age of seventeen (or even earlier) is sometimes regarded as an encouragement to premature leaving: and a boy or girl who has any hope of gaining entrance to a university is regarded as a precious possession. However, State Scholarships directed towards the Technological Award may now be given, and that award may gain prestige even with headmasters. Moreover, those headmasters who rightly protest against the university demand that candidates for science departments should pass G.C.E. at Advanced Level in three sciences (to the exclusion frequently of nearly everything else) will welcome the reduced demand of two science passes recommended for the sandwich courses.

But something else needs to be said. Much that is in the White Paper refers not to the grammar school leaver, but to the boy or girl to be found in the secondary modern school. Some of these will continue, as they do now, to find their way to the professional level as technologists. More of them will become technicians, trained by apprenticeship and day-release courses or, again, by sandwich courses at technical colleges. And the White Paper has nothing to say on what they most need and most lack.

Secondary education for all is too recent a growth to stand up to final judgment, but it is at least time we

began to take stock. At present 20% of the children in England and Wales step up from their primary schools into grammar schools; and the rest, with very few exceptions, step *down*. Only too often they have been unable to recover from failure before the impatience and even resentment of the final year sets in.

What industry needs today, in a severely practical sense, is what society needs as a whole: disinterested, co-operative, generous men and women, at all levels from the highest paid to the lowest. And this is an attitude that comes not from poverty but from richness of life. One of the major aims of real education for any child in its care is to foster the generosity that results from rich and satisfying experience. We need more of this real education, and to get it we shall have, in the first place, to reconsider the structure of secondary education, and in the second, to refuse to be content with narrowly conceived schemes of further training. Enlightened industrial firms have been known to demand a more liberal education for their day-release employees: it appears from the general tone of the White Paper that they may need to make the same sort of demand for their sandwich courses.

EFFECT OF RADIATIONS ON LIVING CELLS

How much is known about radiobiological damage, and what progress has been made in the field of protection against radiation? Few of the questions which are now the subject of scientific research are more topical and arouse a more widespread interest than these. The fact that damage is not only immediate but has grave genetic implications intensifies the general concern with the problem.

One of the now famous Ciba Foundation Symposia was held recently in London to discuss "The Influence of Ionising Radiations on Cell Metabolism". The symposium brought together an international group of workers from many different disciplines, under the chairmanship of Prof. A. Haddow, Director of the Chester Beatty Research Institute.

A number of the scientific papers dealt with effects produced in cells by radiation and by other extraneous agents, such as drugs. Other discussions dealt with studies on the protection of living cells against radiation, and the survival of animals after post-irradiation treatment. The effects of radiation on enzymes, essential constituents of cells, is a further basic problem in this field about which not a great deal is as yet known. Prof. H. A. Krebs from Oxford said that study of some enzymes may be regarded as irrelevant and he indicated lines to follow in selecting the right enzymes for study. This led to the question of what are the energy-giving and energy-consuming reactions interfered with by radiation, and it was concluded that there is an internal control of the organisation of the enzyme system which adjusts the energy supply automatically.

Radiobiological damage to a variety of cells is greater in the presence of oxygen than when irradiation is carried out under anaerobic conditions. This important influence of oxygen was examined in detail by Dr. H. Laser (Cambridge).

Dr. A. Hollaender (Oak Ridge) reported on chemical protection of living cells, including mammalian cells. Here again, information is still limited. Protection may be afforded by treatment either before or after irradiation, and it has been established at Oak Ridge in experiments on mammals, that pre- and post-irradiation treatments work in an additive manner. In mice, either pre-treatment (with chemicals) or post-treatment (with bone marrow or spleen) almost doubles the tolerance to a standard lethal dose of radiation, and combined treatment almost triples the tolerance. He concluded with the promising statement that the possibility exists of the modification of genetic effects by radiation protection. During a general discussion, experiments were described on bacteria suspended in salt solution after irradiation; changes in concentration of the salt solution produced a remarkable increase in the number of bacteria surviving. For example, when bacteria which had been exposed to ultra-violet irradiation were suspended in a calcium chloride solution of known concentration, three or four times the usual number of bacteria were found to survive when plated out. When irradiated bacteria were plated out directly without suspension in salt solution, few survived.

Exciting new evidence was presented to show that when mice which have been irradiated were injected with a suspension of cells from the spleen of unirradiated mice, repopulation of the host from the donor did in fact occur. Dr. Loutit spoke of how pioneer workers had given injections of normal spleen or bone marrow to animals which had received lethal doses of x-rays, and thereby extended the time of survival of such animals beyond the standard thirty days. This was thought to be due to the presence in these tissues of a humoral "recovery factor" which stimulated the damaged tissues to earlier regeneration. But now it has been shown that the regenerating tissues are derived directly from "seeds" of the donated material.

The final session of the symposium was devoted to radiation damage of the genetic material in the cell. Prof. C. P. Swanson of Baltimore speculated on what happens at the chromosomal and physico-chemical levels when the cell is exposed to ionising radiations or to chemical mutagens. Dr. L. H. Gray of Northwood spoke of the sites of energy deposition within the cell which are associated with certain types of radiobiological damage. Among the effects discussed were damage to cell reproduction; this is of special interest in the case of the cancer cell, for instance, where the aim of radiotherapy is to destroy the reproductive integrity of the cell.

Free discussion took place after each paper, and the symposium ended with a general discussion. Although no final solution to the difficult problem of radiation damage at cell level is yet in sight, there can be little doubt that this symposium has greatly stimulated the thoughts of those privileged to take part. The long-term effect of these meetings can hardly be over-estimated when the difficulty and urgency of the radiation problem is considered by the leading scientists working in this field.

UNDERGROUND GASIFICATION

The dream of early 20th-century idealists was that a method of using coal seams could be found which would obviate the need to work underground. The coal was to be "gasified" *in situ* by a steady current of air through a borehole from the surface, a fire having first been started in the coal underneath. Gas would then be obtained from another borehole, and the heating power of the coal would be available at the surface.

Unfortunately the gas which can be obtained in this way is very dilute and has a calorific value between 10% and 20% of ordinary gas. Not only is such a gas unsuitable for many purposes, but it cannot economically be transported. Also, one of the very important uses to which coal is put is the manufacture of coke, an indispensable raw material in iron smelting. Moreover underground gasification would be a wasteful method of exploiting good seams of "minable" coal.

Why has the British Government spent three-quarters of a million pounds since the end of the war in a study of underground gasification? The reason is that there are 300 to 400 million tons of coal lying beneath the soil of Britain which are "unminable" by ordinary methods: the seams may be too thin, or the coal too full of stones and too high in sulphur content.

The technical problems are discussed in the latest Report published by the Ministry of Fuel and Power.* One problem is to find a good method of making an underground connexion, or "linkage" between two adjacent vertical boreholes. Four years ago a method was invented known as "high pressure linkage". Air was forced into the borehole until the pressure was sufficient to lift by a few inches the layers of rock overlying the coal. A fire was started which would form a channel through the gap thus formed. After a while the high pressure could be released and the channel of burning coal would persist, and air could be blown through it at ordinary pressure into an ever-widening reaction chamber.

The present Report shows that this brilliant idea had to be abandoned after many tests, and the same has to be said for another good idea, originating in America—"electro-linkage". This method uses a high-voltage electric discharge to force a path through the coal. Linkages have been satisfactorily made by both methods, but it is difficult to forecast exactly where the passage will go, and the reliability essential for commercial use is lacking. During the last few years attention has been turned to the possibility of drilling a series of holes in the thickness of the coal seam. To be economic, such a hole needs to be perhaps 200 yards long. If the coal seam is 1–2 feet thick, and by no means geometrically flat, very special care is needed to keep the drill running in the coal. A new technique has been developed known as "directional drilling". A firm of specialists prepared the coal seam for several gasification experiments at the two Ministry of Fuel and Power sites.

The Report suggests that the only immediate likelihood of commercial success in underground gasification is offered by the directional drilling technique.

As for a practical scheme, if a 60-megawatt generating station is to be operated, and the process is to go on for twenty-five years, about three square miles of a 3-foot coal seam would be needed. This area would be exploited systematically. On one plan, parallel roads underground would be constructed 500 yards long and 200 yards apart. Boreholes through the thickness of the coal would be constructed running from one road to the next, so that the area would be divided into a rectangular grid. The space between two roads would be the zone in which gasification took place, and other panels would be in preparation so that they could be brought into use when the working panel was exhausted.

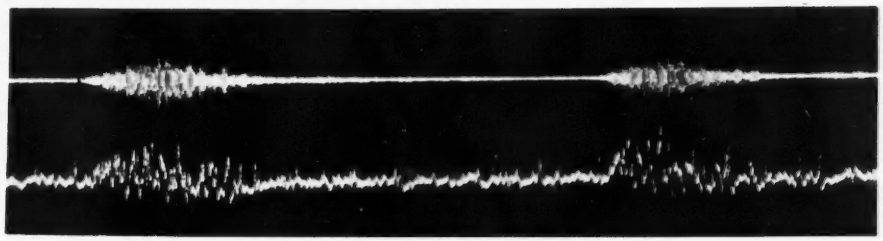
Another possibility is that blind holes might be used, radiating out from a single central shaft. A steel tube would be inserted into each hole, carrying air to the far end where the combustion zone begins. The pattern produced looks like a fan of bulrushes radiating from the central shaft; the head of the bulrush grows longer as gasification proceeds, and the stalk grows shorter. The steel tube burns away at the far end, allowing the combustion zone (the head of the bulrush) to extend towards the shaft. The hot gases travel back by the annular space outside the steel tube, preheating the incoming air very effectively, and at the same time being themselves cooled. Diagrams in the report show the suggested way in which the whole area could be systematically covered by this method.

* "British Trials in Underground Gasification, 1949–55". London, H.M.S.O., 1956. pp. 90. Price 8*s*.

RESEARCH ON ANIMAL SOUNDS

The expression "dumb animals" is a common one; in spite of an abundance of everyday evidence to prove that a large variety of animals can make sounds, there has always been doubt whether they can communicate with one another by means of these noises. Today, however, research is showing that in many animals sound signals play an important part in behaviour and are often connected with mating. The songs of birds, the croaking of frogs, the stridulation of grasshoppers, all play a leading role in the initiation and maintenance of complex behaviour patterns leading ultimately to mating.

Since the war research on animal sounds has greatly increased, and this is mainly due to the new instrumental aids available. To understand why these are important, we must first consider some of the difficulties which beset workers in this field. It has until recently been a troublesome process to make permanent records of animal sounds under field conditions, but the advent of the portable tape recorder has made this very much easier. Another difficulty in sound research arises because the output of many animals is in the ultrasonic range: the cries of bats, the squeaks of certain mice, and some grasshopper songs are examples of such high-frequency noises, and only the development of modern electronic apparatus capable of dealing with these frequencies has enabled them to be recorded. A third difficulty facing the scientist when he has recorded his sound is to find a way of describing its special characteristics. Many biologists in the past evolved



Oscillograph of action potentials in auditory nerve of female grasshopper (lower trace) in response to stimulation by song of the male (upper trace).

notations of their own, often based on the musical scale, but none has ever been satisfactory. The best way is to describe the sound by means of physical standards, such as frequency spectrum, intensity, and waveform, and this can now be done fairly readily by various electronic devices. For example, use of the Sonagraph, a new form of audiospectrometer, greatly assisted the recent discoveries of the manner in which chaffinches build up their song patterns from a simple inherited basis to the complicated final sound by a process of mutual learning with other chaffinches.

The investigation of sound production leads naturally to the investigation of hearing. Electrophysiological techniques now make it possible for workers to record the pattern of nervous discharge from hearing organs when these are stimulated by the sounds emitted by the animal. The figure is an oscillograph record showing impulses in the tympanal nerve of a female grasshopper when stimulated by the stridulation of the male.

Today work is being carried out on the sounds of bats and mice, of whales, porpoises, and dolphins, of many birds, of frogs and toads, and of many insects. Insects have attracted special attention because of the widespread occurrence of sound production in the group, and an international conference was held in Paris in 1954 on the "Acoustics of Orthoptera".

There can now be no reasonable doubt that a large number of animals do communicate by sound, but much work remains to be done in all the groups mentioned above, investigating the mode of production and reception of sounds and attempting to understand how acoustic stimuli initiate or alter various behaviour patterns. So much interest has become focused on this field of biological research that there is now a proposal to set up an international library of recorded animal sounds, and a conference is being held in the United States this year to discuss the project. If such a library could be established it would of course be invaluable to research workers, and would provide a great stimulus to further work in this interesting field.

LIBRARY OF COMPUTER PROGRAMMES

Electronic Digital Computers are very fast and versatile machines but their satisfactory application depends not only on the machine itself, but on the organisation around it. It has been found in practice that an important part of this organisation is the library of subroutines and programmes that is gradually built up over a period of use.

The DEUCE (Digital Electronic Universal Computing Engine) is a first-class example of the type of machine which is performing a valuable service. Apart from the English Electric Co., which produces the machine and uses two machines within its organisation, DEUCE is also being used at the National Physical Laboratory, the Royal Aircraft Establishment, and several other establishments. It is clear, therefore, that enormous saving of effort can result from interchangeability of routines and programmes (other than those in a security classification).

A library of subroutines was set up in the early days of operation of DEUCE. It was based on a similar library built up since 1952 on the Pilot ACE at the NPL from which the present machine stems. Subroutines range from small sets of instructions for performing the regularly used processes of arithmetic such as square root, evaluation of a polynomial or sum of a series, to the more extensive routines for integration and linear algebra. Well over a hundred of these subroutines have been issued to date, contributions to the library having been made by all the present users of the machine, so avoiding any duplication of effort.

Similarly programmes of general interest are contributed to the library by organisations which have a DEUCE. These include test programmes which are used to assist the maintenance engineer to localise any fault which may develop in the machine. Some of the programmes are very extensive and of special value in science and engineering, as for example those for determination of latent roots (real or complex) and vectors of large matrices. For aircraft engineering, programmes to assist in the solution of flutter problems are of particular interest. An extensive scheme designed by NPL for manipulation of matrices deserves special mention because of the versatility of the programmes it contains and the simplicity of application to any combination of matrix operations which can occur in practice.

In order that subroutines and programmes produced by one person can be sufficiently well understood to be used successfully by another, it is essential that a suitable description should be available. Accordingly, the library in the possession of each user contains copies of operating instructions, flow diagrams, and coding sheets, all classified and serially numbered for easy reference. The co-ordination and distribution of these documents is carried out by English Electric as a service to users of DEUCE. A technical news bulletin giving information concerning the activities of the member groups helps to

JOHN DOLLOND, F.R.S.

reduce the chances of work starting in one place when the same work is nearing completion somewhere else.

Great savings of valuable effort are made by the collaboration of users of DEUCE through the library of routines and programmes at a time when such effort is at a premium in this country. These library arrangements are the first of their kind in the world, and will undoubtedly contribute to a much wider and more efficient use of all available computing facilities in England.

JOHN DOLLOND, PIONEER OF OPTICS

The flourishing optical instrument industry in Britain today reminds us of men like John Dollond, born 250 years ago. He came from a silk-weaving family of Spitalfields, descendants of Huguenot refugees named D'Hollande; Dollond himself had a dull routine job in weaving until his hobby of constructing sun-dials and studying mathematics and optics brought him international fame. In 1752 he joined his son Peter's optical business, first established in the Strand and later expanding to workshops in St. Paul's Churchyard. By 1753 this self-taught London optical worker was describing to the Royal Society a combination of eyeglasses for a refracting telescope, first with four and then with five lenses. He improved Savery's micrometer, using only one glass cut into two equal parts with one sliding laterally over the other; a device which soon applied to the reflecting telescope and later to the refracting telescope.

Dollond's achromatic lenses won him the Copley Medal. It will be recalled that Newton had despaired of solving the problem of colour correction, believing that the idea of an achromatic combination of lenses was impracticable. Yet in 1747 Euler in his "Berlin Memoirs" had proposed systems of lenses of glass and water, a proposal which drew Dollond into controversy; by 1758 he himself was reporting to the Royal Society some "Experiments on the Refrangibility of Light" in which he used prisms of water and glass to produce colour without deviation or refraction of light. It was only a matter of time before Dollond was obtaining the reverse or opposite effect, using different types of glass instead of glass and water as media. He ground his wedges of flint and crown glass to overcome what we now know as chromatic aberration, and he saw how the use of smaller apertures would reduce spherical aberration. He put a double concave flint glass lens between two convex crown glasses of lower curvature, and Newton's despairing problem of banishing coloured images was solved. "Thus at last", wrote Dollond, "I obtained a perfect theory for making object glasses, to the apertures of which I could scarcely conceive a limit." Towards the end of his career Dollond retired to compute almanacs for various parts of the world. Added to his honours was the title of Optician to the King. Thus even before Ernst Abbe, working for Carl Zeiss, English "amateur" opticians had accomplished much. Dollond was legally acclaimed the true inventor of the chromatic combination, for he had accomplished in practice what Chester More Hall had done in secret; and even Hall was no professional optician, but an Essex landowner who had studied at the Inner Temple.

ATOMIC ENERGY FOR PEACE

Speaking in Switzerland in 1955 on the problem of atomic energy and peace, President Eisenhower said: "I hope that private business and professional men throughout the world will take an interest and provide an incentive in finding new ways that this new science can be used . . . for the benefit of mankind and not destruction."

The three grandsons of Henry Ford acted immediately and practically upon his suggestion, and proposed to the Directors of the Ford Motor Company Fund that an appropriation of $100,000 be made annually for ten years for the advancement of the science of atomic energy for peaceful purposes. The Directors of the Fund thereupon set up a body to be known as "Atoms for Peace Awards Inc.", the trustees of which will select from among the world's scientists and engineers, without discrimination of nationality or political belief, the individual or group of individuals who have made the greatest contribution to peaceful uses of atomic energy. The prize-winner or prize-winning group will receive an honorarium of about $75,000.

Nominations for the award may be received from individuals or organisations in any part of the world. Judgment will be based on information freely available in the public domain, and will not take into account information and data of a "classified" or secret nature.

ON THE POSSIBILITY OF PRODUCING THERMONUCLEAR REACTIONS IN A GAS DISCHARGE

I. V. KURCHATOV

On April 25, 1956, Dr. I. V. Kurchatov addressed a scientific meeting at Harwell. His speech proved of very great interest and was widely reported the next day in the Press. The first full publication of the complete text appears below, as translated from the Russian by the Academy of Sciences. It is given without any alterations, additions, or deletions, and with all the original illustrations. It is hoped to comment more fully on this paper in the next issue of DISCOVERY.

Among the more important problems of modern engineering science the utilisation of energy of thermonuclear reactions is a problem of foremost significance. Physicists over the whole world are attracted by this extraordinarily interesting and very difficult task of controlling thermonuclear reactions.

Investigations in this field are being carried out by Academician Artsimovich at our Institute. A leading role in the theoretical investigations was played by Academician M. A. Leontovich.

As is well known, thermonuclear reactions can arise if the temperature of matter is sufficiently high for atomic nuclei to surmount with appreciable probability the forces of the Coulomb barrier during thermal collisions. The excitation of thermonuclear reactions in deuterium or in a mixture of deuterium and tritium is especially interesting as in this case a noticeable effect should be obtainable at relatively low temperatures. Physics is indebted to the founder of nuclear physics, Ernest Rutherford, for information regarding the interaction of deuterons. In one of his last investigations Rutherford studied the nuclear reactions which occur when two deuterons collide. It was difficult to suspect at that time that the new facts discovered by him would make more realistic our hope of mastering the energy sources which up to now have existed only in the hot remote parts of the sun and distant stars which shine above us.

The intensity of thermonuclear reactions in deuterium should greatly increase with the temperature up to temperatures of several billion degrees.

A notion regarding the conditions under which thermonuclear reactions should be experimentally observable can be obtained by considering some concrete cases.

In deuterium, whose density equals that of a solid body under normal conditions, a temperature of 2.10^5 degrees would be required to obtain one neutron per second per gram of deuterium. If the deuterium were a highly rarefied gas with a concentration of about 10^{23} atoms per cm^3 a temperature of about 5.10^5 degrees would be required to produce some effect in a gram of deuterium which would occupy a volume of 30,000 m^3.

Thus, even to approach the threshold for production of thermonuclear processes the temperature of matter must be raised to a very high level. At such temperatures and under stationary conditions the deuterium should be an almost totally ionised plasma.

The amount of energy which must be concentrated in the plasma to raise its temperature to a level sufficient for the production of intense thermonuclear reactions should be comparatively small. Thus, the amount of thermal energy necessary to raise the temperature of one gram of deuterium to 10^6 degrees equals only a few kilowatt hours. This is about the same amount of energy required to boil water in a family samovar.

Therefore, if one were able to invent a method of heating the plasma with practically no thermal losses, even a low power energy source could be used to induce intense thermonuclear processes. The main problem is to exclude heat losses which rapidly increase with the temperature since the thermal conductivity of the plasma is proportional to $T^{5/2}$.

When matter is heated to a temperature of only several tens of thousand degrees the losses in the absence of thermal insulation will be so great that further increase of temperature will be practically impossible.

There is another obstacle which arises when dense substances are heated: one must overcome the enormous mechanical forces which result from increase of the pressure with temperature. On heating initially solid or liquid deuterium we find that already at $T=10^5$ degrees the pressure exceeds a million atmospheres. Therefore, thermonuclear reactions can be induced only during a very short period of time in dense substances, and such a process will always resemble an explosion (which, however, may not be dangerous) or a brief pulse.

On considering the various ways of generating intense controllable thermonuclear processes one finds that there are quite a number of directions which may be followed in attempting to solve this problem.

On the one hand there are the approaches which lead to stationary thermonuclear reactions and on the other, those which are based on the idea of utilising an instantaneous temperature rise in transient processes of very brief duration. However, irrespective of the way the investigation is carried out there is one problem that is inevitably encountered, namely, the isolation of the plasma heated to a high temperature from the walls of the vessel in which it is confined. In other words a means must be found to keep the fast particles within

the plasma over a period sufficient for the particles to have a good chance to react with each other.

One of the ideas proposed in connection with this problem was that of using a magnetic field for thermal insulation of the plasma. Academician Sakharov and Academician Tamm were the first to point out this possibility in 1950. In a sufficiently strong magnetic field electrons and ions can freely move only along the lines of force. In a plane normal to the lines of force the particles will move along circles of small radius. The positions of the centres of these circles can vary only as a result of collisions, each collision displacing the centre by a distance of the same order of magnitude as the radius of curvature of the particle trajectory. If the radius of curvature of the trajectory is small compared to the mean free path, diffusion of the particles and thermal conductivity of the plasma in the plane normal to the magnetic field will be greatly diminished. The theory of processes taking place in completely ionized plasma indicates that at high field strengths, H, and high temperatures the transverse thermal conductivity coefficient is inversely proportional to H^2 and decreases by many orders of magnitude with respect to the value found in the absence of a magnetic field. Under these conditions, however, radiation losses must be taken into account.

The magnetic field required to provide the thermal insulation may be produced by passing a sufficiently intense current through the plasma. The current will also heat the plasma as a result of Joule losses and of the work of electrodynamics forces. These considerations were the basis for carrying out theoretical and experimental studies of the physical processes which occur in a plasma on passage of intense currents.

We shall first examine the principal theoretical concepts which preceded the experimental work. When a current is passed through a plasma the latter should contract under the action of electrodynamic forces (attraction of parallel currents). An increase of plasma temperature should follow. If a contracted column of the plasma is detached from the vessel wall as a result of electrodynamic contraction ("pinch" effect) its temperature may be estimated from the condition that the pressure of the ionized gas is balanced by the electrodynamic forces. A simple computation shows that in such quasi-stationary contraction processes the plasma temperature should be proportional to the square of the current. As is well known, if the electrons and ions are in thermal equilibrium, the plasma temperature can be expressed by the equation:

$$T=\frac{I^2}{4Nk},$$

Here I is the current expressed in electromagnetic units, N is the number of particles of a given sign per centimetre length of discharge tube, and k is the Boltzmann constant. Investigation of the conditions of thermal equilibrium showed that for $N\sim10^{17}$ the electron and ion temperature should be practically identical. At appreciably lower values of N only the electron temperature will increase.

A contracted plasma column detached from the walls can exist only as long as the current is building up. If the current is constant the column will disintegrate and come in contact with the walls.

It is evident that a thermonuclear reaction with a constant yield over an appreciable period of time cannot be produced by passing a current through a plasma. In principle it should be feasible to periodically heat the plasma and induce thermonuclear reactions in phase with the peak current. Calculations of the expected thermonuclear effect led to the following result which at first glance may seem paradoxical. It was found that during a single heating cycle the total number of elementary nuclear interaction acts pertaining to a given value of the peak current should be independent of the duration of this cycle. Thus, it seemed that it should be possible to excite very intense thermonuclear reactions by sending pulsed discharges of very short duration through deuterium on the condition that the current was sufficiently large. Theoretical calculations indicated that already a current of 300 ka should be sufficient to produce an appreciable emission of neutrons of thermonuclear origin. At currents of several million ampères the emission should be very intense. Such were the theoretical predictions which preceded the experimental work.

Further development of the conceptions regarding the nature of the processes occurring in a plasma during the passage of an intense current was profoundly influenced by the new facts discovered during experimental investigation of powerful pulsed discharges. These results completely altered the landscape and colours of the picture created by the first spurts of theoretical effort.

Experimental investigation of intense pulsed discharges was carried out in a broad range of the parameters characterising the initial discharge conditions.*

Discharges through hydrogen, deuterium, helium, argon, xenon and gas mixtures (deuterium-helium, deuterium-argon, deuterium-xenon) of various relative content were studied. The measurements were carried out as gas pressures ranging from 0·005 mm Hg to one atmosphere. Most of the experiments were performed with straight discharge tubes. The length of the discharge gap varied from several centimetres up to two metres and the diameter from 5 to 60 cm. The discharge was produced by a voltage of several tens of kilovolts. The peak current varied from 100 ka up to two million ampères, the rate of build-up of the current lying between 10^{10} a/sec and 10^{12} a/sec. The maximum instantaneous power released in the plasma in these experiments attained as much as 40 million kilowatts.

Banks of high-voltage condensers were used to produce the discharges. The leads which carried the current from the condenser to the discharge gap were designed in such a manner as to keep the parasitic inductance of the electric circuit down to minimum, since this factor

* In England pulsed discharges in gases have recently been investigated by I. D. Kraggs and his collaborators, S. W. Cousins and A. A. Ware, and others. [Author's footnote.]

restricted the magnitude of the current and its rate of growth. For a voltage of 50 kv and total capacity of the condenser bank of several hundred μF the parasitic inductance of the circuit and switch was only 0·02–0·03 microhenry (in those cases when the current growth was maximal).

Oscillographic methods of measurement of the main parameters characterising the state of the plasma during passage of a current were developed and these were used to study the intense pulsed discharges. Besides oscillography ultra-high-speed moving picture cameras (up to 2 million frames per second) were used as well as photography by aid of Kerr cells supplied with special electro-explosive types of shutters.

In addition to the discharge current and voltage, oscillograph records were also made of the intensity of separate spectral lines from the plasma, of the neutron and x-ray intensity, of the magnitude of pressure pulses measured with the aid of piezoelectric elements and also of the instantaneous magnitude of the magnetic and electric field strengths at various points within the plasma. The magnetic and electric fields were measured with small probes in the form of miniature coils, loops or needle electrodes of various shapes which could be placed at various points within the discharge vessel.

Space limitations do not permit me to give a detailed account of the numerous results obtained in this series of experiments, and I will therefore report only a small part of the available experimental material.

Of greatest interest is the first phase of the discharge during which the plasma current rises from zero to the peak value. On the experiments discussed here this phase lasted from 3 to 30 microseconds. At the beginning of the discharge after breakdown of the gas a smooth increase of the current and voltage in the discharge gap takes place. After a certain period of time a sharp decrease of the voltage occurs. At the same time a more or less pronounced kink can be seen on the current oscillogram (see Fig. 1 which illustrates the general nature of time variation of the current and voltage and also the oscillograms on Figs. 2 and 3). After the first drop the voltage began rapidly to increase and then sharply dropped again. This second voltage decrease was paralleled by appearance of a new kink on the current oscillogram. In some cases three consecutive sharp changes in the otherwise smooth variation of the current and voltage was observed at the first stage of the discharge.

These characteristic features of high current pulsed discharges are especially pronounced when the discharge takes place in gases of low atomic weight (hydrogen, deuterium, helium) and at low initial pressures.

When the rate of current build-up is of the order of 10^{11} a/sec the interval between breakdown of the gas and appearance of the first voltage drop comprises several microseconds.

This time interval is a regular function of the parameters characterising the initial conditions of the discharge. For a given discharge tube diameter it approximately varies as the fourth root of the gas mass per centimetre length of the discharge gap.

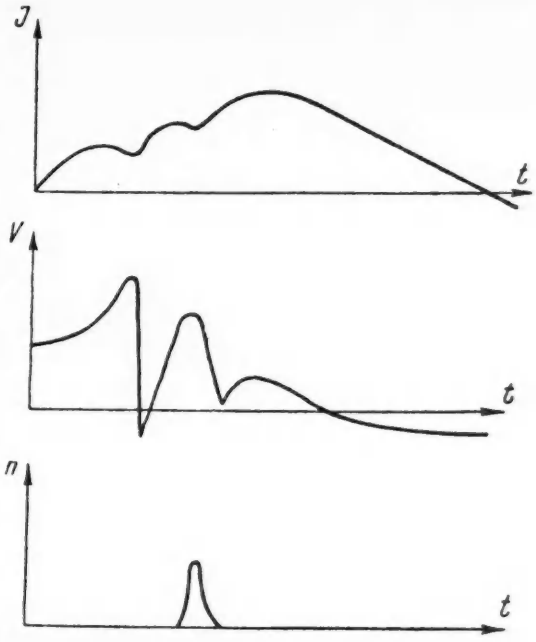


FIG. 1.

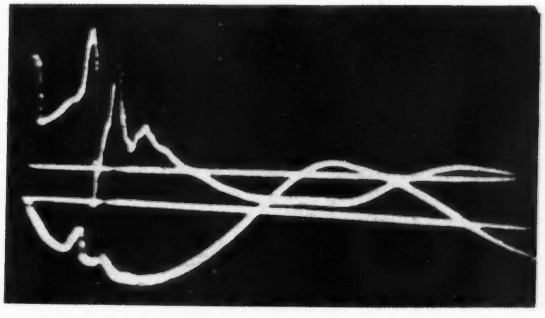


FIG. 2. Oscillogram of current and voltage in a discharge in deuterium at $V_0 = 40$ kv and $P_0 = 5 \cdot 10^{-2}$ mm. Hg.

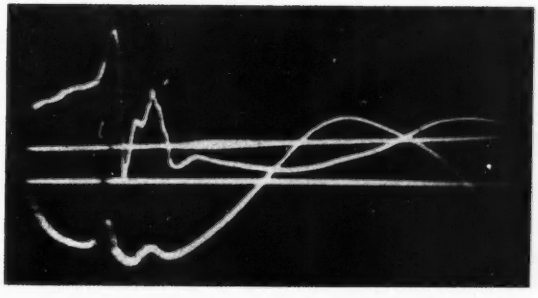


FIG. 3. Oscillogram of current and voltage of a discharge in deuterium at $V_0 = 40$ kv and $P_0 = 0{\cdot}2$ mm. Hg.

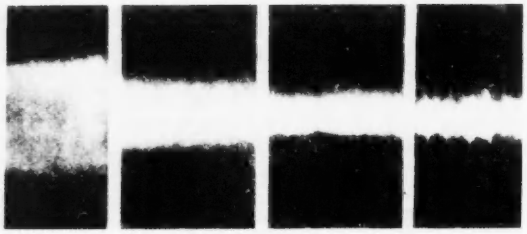


FIG. 4.

The inductive resistance is much larger than the ohmic one in pulsed discharges in which the current increases at a high rate. Thus, by using current and voltage oscillograms one may find the time dependence of the inductance of the plasma column and hence determine how the radius of the column changes at various stages of the process. An analysis of this type indicates that in all cases the very first stage of the process featured by an increase of the inductance due to contraction of the plasma towards the discharge tube axis. The speed of constriction of the plasma increases with the initial current build-up rate, (that is, with the derivative $\frac{dI}{dt}$) and decreases with the gas density. At the moment when the kink on the current oscillogram appears and a sharp drop in the potential is observed the inductance begins to decrease. This means that this moment corresponds to maximum contraction of the plasma filament. This situation is followed by a rapid expansion of the plasma filament. The appearance of several kinks on the current oscillogram signifies that consecutive contractions and expansions of the column take place.

These conclusions which were obtained by analysing current and voltage oscillograms are confirmed by data obtained by applying ultra-high-speed cinema photography of pulsed discharges of tubes with transparent walls. On the accompanying photograph (Fig. 4) are shown four successive frames of a moving picture of a pulsed discharge in deuterium at a pressure of 0·1 mm Hg and peak current of about 200 ka. These pictures were taken at intervals of 0·5 microsecond and refer to only a very small period of development of the process which corresponds to the current and voltage break. The minimum plasma column diameter corresponds exactly to this moment (the moving picture frames were phased with the current and voltage oscillograms).

The next photograph (Fig. 5) was obtained by using a moving picture camera for continuous photography. In this method a narrow slit perpendicular to the axis of the discharge tube subtends a small segment of the discharge gap whose image is swept across the film at a high speed. As a result, a continuous picture of variation of the diameter of a small segment of the plasma column was obtained on the film. The photograph shown here was obtained for a discharge in deuterium with a peak current of about one million ampères. The initial gas pressure was 10 mm Hg. The moment of maximum contraction and the further development of the process are clearly visible.

A photograph of the contracting plasma column obtained with aid of a Kerr cell is shown in Fig. 6 [and 7]. Valuable data on the main physical processes occurring in intense pulsed discharges can be obtained by measuring the magnetic and electric field strengths in plasma. Magnetic field measurements permit one to draw the following picture of current distribution in the plasma. Directly after breakdown the current conducting region is a thin cylindrical layer adjacent to the discharge tube walls. The inner boundary of this layer at first slowly and then more rapidly moves towards the axis. After a certain interval of time the current fills the whole tube as a result of movement of the inner current boundary. The moment at which the current reaches the axis practically coincides with the time of appearance of the first kink on the oscillogram.

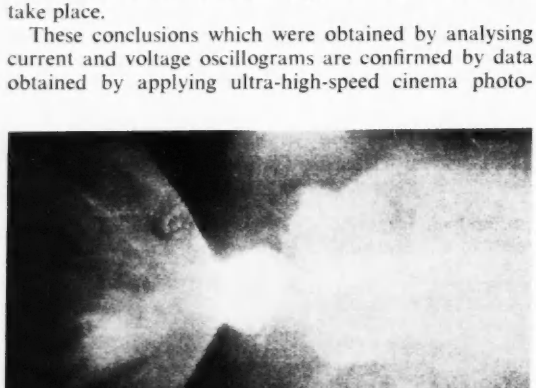


FIG. 5. Photographic sweep of a discharge in deuterium at a pressure P_0=10 mm. Hg. Semi-spherical electrodes. Distance between electrodes 45 mm. Scale of sweep 1 μsec.=18 mm. I_{max}=1·2.10^6 a. T/4=9·5 μsec. Diameter of chamber 180 mm.

The current density near the discharge axis at this time exceeds the mean current density over the cross section of the tube by several dozens of times. On subsequent expansions and constrictions the current density remains very high in a central region of several centimetres in diameter although appreciable fluctuations are observed.

The current density distribution over the cross section of the discharge tube at various periods of time is schematically shown in Fig. 8. The current density distribution at the very first stage of the discharge is shown in the left figure. The second one refers to the moment when the current was moving towards the axis. The distribution after the first contraction of the plasma column is illustrated in the right figure. An interesting feature of this stage of the process is that in a certain zone of the discharge the current reverses its direction.

The velocity of the ionised gas is the quantity which directly characterises the dynamics of a pulsed discharge.

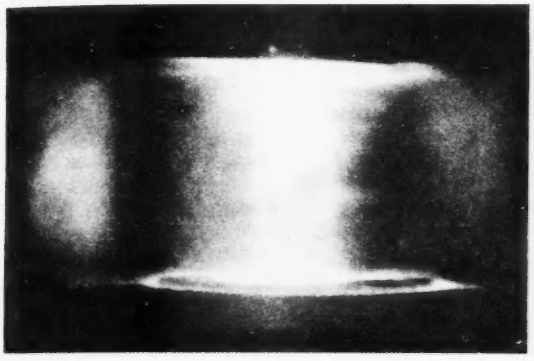


FIG. 6. Moment of contraction of the discharge column. Exposure 0·2 μsec. Photograph made with Kerr cell. Discharge in deuterium at pressure P_0=1 mm. Hg. Distance between electrodes 45 mm. Diameter of vessel 180 mm.

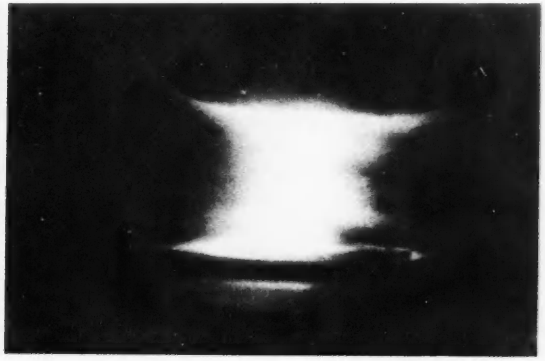


FIG. 7. Photograph made with Kerr cell, 2·2 μsec. after commencement of discharge in deuterium. Initial pressure P_0=1 mm. Hg. Exposure 0·2 μsec. Distance between electrodes 40 mm.

In a plasma of sufficiently high conductivity this velocity is determined by the ratio between the longitudinal electric field strength E and the magnetic field strength H:

$$v = \frac{cE}{H}.$$

Measurements of E and H indicate that in a pulsed discharge with rapid growth of current the radial velocity of the plasma may be very high. In the experiments described here the maximal velocity during contraction and expansion of the plasma column in rarefied gases was found to reach hundreds of kilometres per second. This signifies that the kinetic energy of the drift of the plasma ions is of the order of several hundred electron-volts.

One of the most interesting effects observed in intense pulsed discharge in light gases is the appearance of penetrating radiations. In 1952 soon after experiments with pulsed discharges were started it was found that at sufficiently high currents the discharge in deuterium becomes a source of neutrons.

The first experiments performed with the aim of studying this phenomenon showed that the neutrons appear under conditions when the peak discharge current is 400–500 ka and the initial deuterium pressure is about 0·1 mm Hg. The neutron emission was observed in a relatively narrow pressure range and its intensity rapidly increased with increase of the applied voltage, i.e. with increase of the peak current. In these first experiments the radioactivity induced in a silver target embedded in a paraffin block placed near the discharge tube served as the neutron detector. A possible explanation of this phenomenon was that the neutron emission resulted exclusively from collisions between the accelerated deuterons and deuterium adsorbed by the electrodes on tube walls; control experiments however did not confirm this explanation.

At the early stages of investigation it was quite natural to assume that the neutrons resulted from thermonuclear reactions in the plasma heated to a high temperature. This was exactly what was expected from the beginning and the fact that the effect was detected under conditions which completely corresponded to the *a priori* theoretical predictions seemed to speak in favour of this viewpoint. The behaviour of the neutron radiation (its dependence on pressure and current) observed in the first experiments qualitatively concorded with the assumption that the phenomenon was due to thermonuclear mechanism. However, very soon serious doubt concerning the correctness of this assumption began to appear. This happened after it was found that neutrons can be observed at comparatively small discharge currents, of the order of 150 ka. According to the initial calculations the intensity of the thermonuclear reaction at currents of 150 ka should practically be zero.

In subsequent experiments the neutrons were recorded with scintillation counter fed to an oscillograph. This technique made it possible to find the relation between the discharge properties and the moment of appearance of neutrons. It was found that the neutrons were always emitted when the second kink appeared on the current oscillogram, i.e. at the moment when the plasma was subjected to the second contraction (Fig. 9). No neutrons were produced during the first contraction. The neutrons were always emitted as short pulses with a steep front. The rise time of the pulses was several

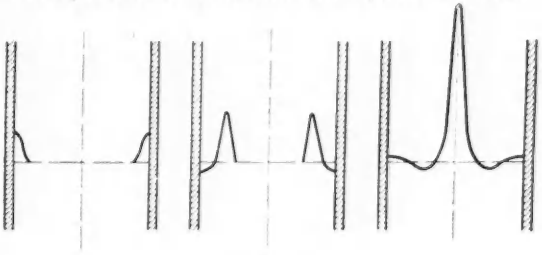


FIG. 8

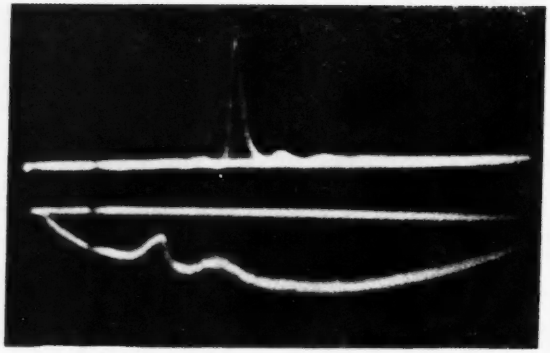


FIG. 9. Oscillogram of current and neutron pulse of a discharge in deuterium at $V_0 = 40$ kv and $P_0 = 10^{-2}$ mm. Hg.

tens of microseconds. The chief results of the oscillographic investigations were not consistent with the initial assumption that the neutron emission is the result of quasi-stationary heating of the plasma, during which the temperature increases proportionally to the square of the current.

Further investigation yielded new interesting facts pertaining to the plasma neutron radiation. It was established, in particular, that in specially designed discharge tubes the neutrons could appear at fairly high deuterium densities, as much as several tens of millimetres of initial pressure. This fact signified that the neutron emission was certainly not a trivial effect.

It was found that not only neutrons but hard x-ray as well were produced in pulsed discharges. Penetrating x-rays were found when large currents were passed through hydrogen, deuterium and helium. The radiation produced by discharges in deuterium always consisted of short spurts. The pulses due to the neutrons and x-ray quanta always appeared simultaneously on the oscillograms. The energy of the x-ray quanta produced in pulsed electrical processes in hydrogen and deuterium reached 300–400 kev. It is noteworthy that at the time of emission of such high-energy quanta the voltage applied to the discharge tube was only about 10 kv.

Theoretical analysis of the complex phenomena which occur in the plasma of a pulsed discharge oscillating under the action of electrodynamic forces is still at such a stage that quite a number of facts remain to be explained. However, the general picture of the process is gradually becoming clear and some of the peculiarities of the phenomenon seem to have been sufficiently elucidated.

It is now clear that contraction and expansion of the plasma are not quasi-stationary processes characterised by equilibrium between the external and internal pressures.

In the equations describing the dynamic of a pulsed discharge the main term is that which accounts for momentum changes in the ionised gas due to magnetic pressure. The kinetic energy of the ordered motion should at some stages of the process therefore greatly exceed the thermal energy concentrated in the plasma.

At the initial stage of the discharge the internal pressure in the plasma is very small and the electrodynamic forces therefore produce acceleration along the radius towards the discharge tube axis. Thus, the work of the electrodynamic forces is not expended in raising the temperature but in imparting kinetic energy to the converging plasma layer. At this stage the discharge tube operates as a peculiar type of accelerator in which the particles are driven by the magnetic field. Since charged particles, irrespective of sign, will move with the same velocity the kinetic energy acquired by the ions will be quite large whereas the kinetic energy of the electrons practically will not change in virtue of the small mass of these particles. From the viewpoint of gas dynamics the contraction process should be considered as a phenomenon in which a cylindrical shock wave converging towards the axis is produced in the plasma. At first, the gas located before the inner wave front is not ionized. When the wave begins to move the gas is carried along together with the charged particles of the plasma and its atoms simultaneously become ionized. The amount of matter which begins to move gradually increases and the total amount of ions and electrons in the plasma rapidly increases. The duration of the contraction phase can be determined by calculating the velocity acquired by the contracting gas. It was found to be approximately proportional to $\sqrt[4]{\frac{M}{V_0^2}}$, where M is the mass of gas per unit length of discharge tube and V_0 is the initial voltage. This is exactly what one finds experimentally for the interval between breakdown and appearance of the first kink in the current oscillogram.

The final stage of cumulative contraction sets in when the plasma accelerated by the magnetic field reaches the axis. At this moment a great part of the energy of ordered motion changes into heat and the pressure and plasma temperature sharply increase. During maximum contraction the plasma temperature may be of the order of one million degrees. The nature of the processes occurring during maximum contraction are not very clear but apparently after maximum cumulation a diverging shock wave should appear which drives the plasma towards the walls. Inside the outgoing wave there should be a rarefied zone. Under the action of electrodynamic forces which tend to compress the current the outgoing wave should be abruptly decelerated and a new phase of contraction should ensue. This stage differs from the first in that the density in the inner region of the discharge is small and the gas in this region is probably almost completely ionized. As a result, during the second contraction conditions are produced which are favourable for accelerating in the longitudinal electric field of a certain group of ions and electrons located near the discharge axis, i.e. in the region in which the magnetic field is small. One may note here a certain analogy with the accelerating mechanism proposed by Fermi in his theory of origin of cosmic rays. A plasma of high conductivity will

move together with its magnetic field, and with respect to particles located in the inner zone it will be equivalent to a converging magnetic wall from which the enclosed electrons and ions will repeatedly be reflected, their energy increasing after each reflection. Acceleration of ions and electrons in the longitudinal electrical field near the discharge axis is possibly the explanation of appearance of neutrons and penetrating x-rays. The electric field strength during the second contraction may be very high. It may exceed the instantaneous external voltage applied to the discharge tube by many times.

However, it must be mentioned that not all in this acceleration mechanism is yet clear. Under certain conditions acceleration of ions in a longitudinal electric field may also be possible outside the central zone of the discharge due to the presence of space charges. Some types of unstability which are peculiar to the column may play an important role in accelerating particles in the plasma. In particular, one type of unstability observed experimentally may be of importance for acceleration of electrons. It consists of spontaneous creation of a longitudinal magnetic field in the plasma as a result of spiralling of the plasma column.

If the second contraction is followed by a few more oscillations of the plasma column the acceleration of the particles may be repeated several times. Experimentally not more than three successive oscillations have been observed. A possible explanation of this is that the plasma may begin to interact with the discharge tube walls with the result that the wall material begins to evaporate and appreciable amounts of foreign gases appear in the volume.

We considered here some features of the phenomena which accompany the passage of intense pulsed discharges through rarefied gases. The success of further work in this direction will greatly depend on the possibility of creating conditions under which the plasma column will experience multiple oscillations during build-up of the current without coming into contact with the walls. However, there are serious reasons to believe that this cannot be achieved.

On appraising the various approaches to the problem of obtaining intense thermonuclear reactions we do not deem it possible to completely exclude further attempts to attain this goal by using pulsed discharges. However, other possibilities must also be carefully considered. Especially interesting are those in which the idea of stationary processes may be used.

SEA-SPIDERS

THEODORE H. SAVORY, M.A., F.Z.S.

There are no spiders in the sea; but there are some very curious animals named "sea-spiders", a title more fitting than the alternative "nobody-crabs". Actually they are neither crabs nor spiders; they are the Pycnogonida, also known as Pantopoda and Podosomata.

Though marine animals, they have no adaptations for swimming. They have such small abdomens that their stomachs and ovaries are pushed into their legs. They entrust the collecting of the eggs and carrying of the young to the males. A zoologist should hesitate to laugh at any animal, but he might be excused for smiling at a sea-spider.

Not many more than four hundred species have been described, and they have come from the floor of the ocean in all parts of the world, wherever the water does not contain less than 3·5% of dissolved salts. Some are littoral and may be found between the tide-marks on the coasts of Britain; many live in deeper waters; and a few are abysmal, occurring at 1500 fathoms. They are plentiful in the polar seas; and the Antarctic, which appears to be their headquarters, has provided some of the most remarkable species.

STRUCTURE

The general structure of a fully developed sea-spider is shown in the drawing of *Nymphon* (Fig. 1). The body is divisible into four regions, each of which carries a pair of long legs. The foremost portion also carries a tubular proboscis and three pairs of appendages: the pincer-like chelophores, the sensory pedipalps, and a pair of ovigerous limbs (egg-carriers). Thus a normal sea-spider has seven pairs of appendages; all true spiders have six pairs. Another difference between spiders proper and sea-spiders is that in the latter each of the four portions of the body—the prosoma as it is called—is produced at the sides into processes or projections to which the legs are attached. These processes are sometimes short and close together, sometimes longer and well separated. The proboscis is a simple tubular organ with a triangular mouth opening on its extremity.

The representative of the group most often to be

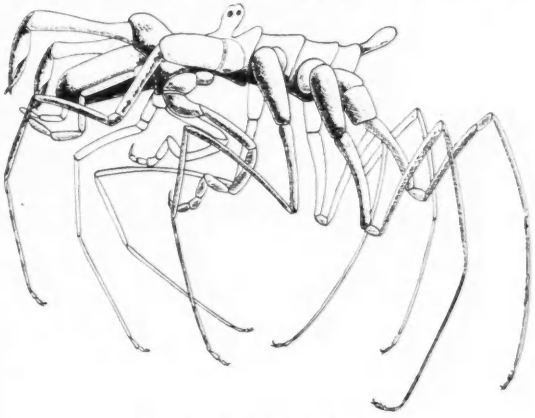


FIG. 1. A Pycnogonid (*Nymphon*)

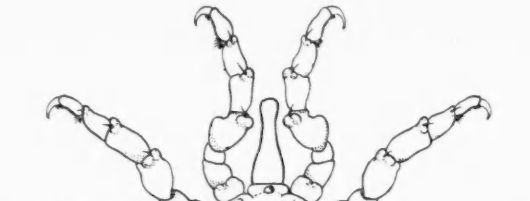


FIG. 2. *Pycnogonum littorale*

found on our shores is the well-known *Pycnogonum littorale* (Fig. 2). It was historically one of the first species of sea-spiders to be noticed by a zoologist; it was described by the Norwegian, H. Stroem, in 1762, and his original drawing is reproduced here (Fig. 3). He called it *Phalangium littorale*. (Phalangium was at that time the name of a genus included among the insects; it is now a characteristic genus of the harvestmen.)

In searching or trawling for Pycnogonum one is likely to find a second almost equally common British species, *Chilophoxus spinosus*, a very different-looking creature. Whereas Pycnogonum is a solidly-built animal with short stumpy legs, and may be 2 centimetres long, Chilophoxus is about 5 millimetres long, with a thin elongated body and long thin legs. Pycnogonum is yellow or brown, Chilophoxus is green, often with red marks, and carries its little abdomen vertically. The lateral leg-bearing processes are widely separated, and it has a characteristic collar round the base of its proboscis.

These two common species have not the full supply of limbs, for they possess neither chelophores nor pedipalps. It is a peculiarity of the sea-spider that some families have both chelophores and pedipalps, some have chelophores only and some have neither.

Writers often describe the Pycnogonida as parasites on hydroids: they might more accurately be described as semi-parasitic. Some have been seen to seize the hydroid heads in their chelophores, tear or cut them off and carry them to their proboscis, which rapidly sucks them in. But sea-spiders which have no chelophores can only plunge their proboscis into the body of their victim and extract nourishment by suction, a typically parasitic action. Besides infesting coelenterates, the Pycnogonida have also been found on the bodies and gills of molluscs.

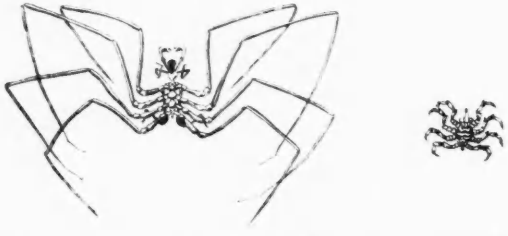


FIG. 3. Strom's original drawings of *Nymphon* and *Pycnogonum*.

In all its actions a sea-spider is amazingly slow and deliberate. Those with short legs creep cautiously about like snails; those with long legs can almost swim; at least they can support themselves in the water by moving their legs up and down. The female lays her eggs in spherical bunches; and it was discovered by Cavanna, an Italian, in 1877, that they are then collected by the male and carried on his ovigerous legs. His paternal care does not amount, however, to more than an offer of temporary transport. The eggs of some genera hatch as nymphs, of others as larvae. A larval sea-spider is a very peculiar creature (Fig. 4) possessing

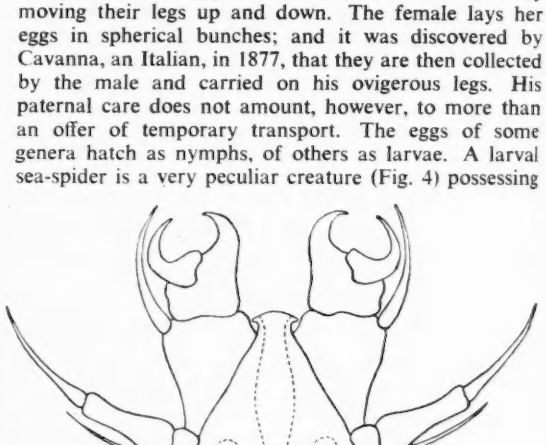


FIG. 4. Larva of a pycnogonid.

the sucking pharynx and three pairs of appendages. In some species the claws of the second and third pairs are prolonged so that they can coil round objects and anchor and support the larva. Thus it comes about that gradually they part company from their parent and start life on their own. They feed on the walls of the gastro-vascular cavity of the coelenterate in which they take shelter, and grow by the usual method of periodic moulting. Among the inhabitants of the sea they rank as organisms well worth further study.

CLASSIFICATION

Sea-spiders have always commanded a certain amount of attention because they do not fall readily into place in the conventional scheme of classification. There is, of course, no reason why they should, for animals were not created to form a satisfying series of grades and groups, and the problem is rather to construct a scheme into which all discoveries will fit.

From the ecologists' point of view a very neat plan is evident. On the land, insects are numerous and, as writers often metaphorically describe them, successful; while the arachnids are less numerous and less successful. In the sea, the crustaceans are the dominating and successful arthropods; and the sea-spiders are the less numerous and less conspicuous. There is thus the suggestion that the sea-spiders are the marine parallel to the terrestrial Arachnida. Although zoological classification is not based on ecological considerations, the first impression which the sea-spiders give is, in fact, an apparent relation to the Arachnida.

The following resemblances are obvious: (i) the possession of four pairs of legs; (ii) the situation in front of the mouth of one pair of chelate appendages; (iii) lateral caeca from the mid-gut, like those of spiders; (iv) simple eyes; (v) an ocular tubercle, like that of harvestmen. At the same time differences between the two groups are also obvious; for no arachnid has the lateral extensions of the cephalo-thorax to which the legs of the sea-spider are attached; and the ovigerous legs, which make three pairs of appendages in front of the first true legs, are organs which no arachnid possesses.

The significance of the common possession of eight legs is reduced by the existence of a few sea-spiders with more. Such a variation in the number of important and active limbs is a truly remarkable phenomenon, and one which cannot easily be paralleled in other groups. It is one of the most striking features of the zoology of the pycnogonids.

As long ago as 1834, J. Eights described a polar species with ten legs and named it *Decolopoda australis*. His account was scarcely credited, and was half forgotten, but in 1904 J. V. Hodgson described a ten-legged genus Pentanymphon, collected by Scott's *Discovery* expedition. The following year he redescribed Decolopoda, which had been brought back by Bruce's *Scotia* expedition. A little later E. L. Bouvier described a third genus Pentapycnon.

The striking feature of these genera is that they do not form a natural group, but closely resemble eight-legged forms, even in trivial details. The experts have not yet agreed as to whether eight legs are ancestral to ten, or ten legs to eight; and their speculations were in no way simplified when in 1933 W. T. Calman and I. Gordon of London's Natural History Museum described a new species with twelve legs. The specimen, a male, had been taken off the coast of MacRobertson Land, in 66° 45′ S., in 1931.

Dodecolopoda mawsoni, as it is called, can claim to be one of the most interesting animals in the world. It is enormous; unlike the European species, most of which cover a few millimetres, this specimen spans about twenty inches. Nor can it be regarded as just a Decolopoda plus an extra pair of legs, for Decolopoda has its extra pair situated in front of the ovigers, while Dodecolopoda has all its six pairs behind its ovigers. There are at present a number of expeditions working in Antarctica, and it is to be hoped that more knowledge about these animals will be collected.

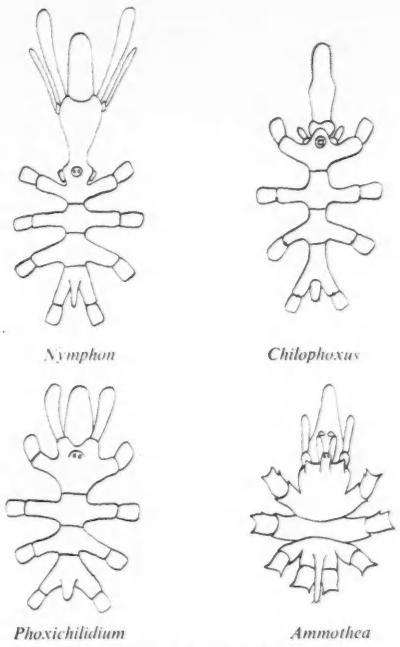


FIG. 5. Four common British genera.

BRITISH SPECIES

British naturalists, however, need not depend on polar explorers in order to gain some degree of first-hand acquaintance with these really extraordinary animals. About a couple of dozen species have been taken from comparatively shallow water near our coasts, so that they may reasonably be included as part of the fauna of the British Isles, and about a third of these are truly littoral—well-known species which can be collected on the beach. *Pycnogonum littorale* and *Chilophoxus spinosus* can often be found in masses of growing seaweed carried back to the laboratory.

In many places at least three other species are likely to be found—*Phoxichilidium femoratum*, *Nymphon rubrum* and *Ammothea echinata* (Fig. 5).

Readers interested in marine life can exercise their powers of accurate observation and careful diagnosis by searching for sea-spiders. Here is an opportunity to investigate the life-histories of little-known creatures.

Figs. 2 and 4 are reproduced from T. H. Savory's "The Arachnida", published by Edward Arnold.

READING LIST

The most readily available account of sea-spiders is that in the "Cambridge Natural History", it is forty-five years old but is well worth study. There is a short account of the British species in "Spiders and Allied Orders of the British Isles", in Warne's *Wayside and Woodland* series: and there are two very useful papers, by T. V. Hodgson in *Trans. Devon Assocn.* for 1910 and by Marie Lebour in *J. Marine Biol. Assocn.* for 1945.

E. L. Bouvier's section in the "Faune de France" is admirable, and an exhaustive monograph is that by H. Helfer in Bronn's *Klassen und Ordnungen*.

NUCLEAR POWER FOR AIRCRAFT

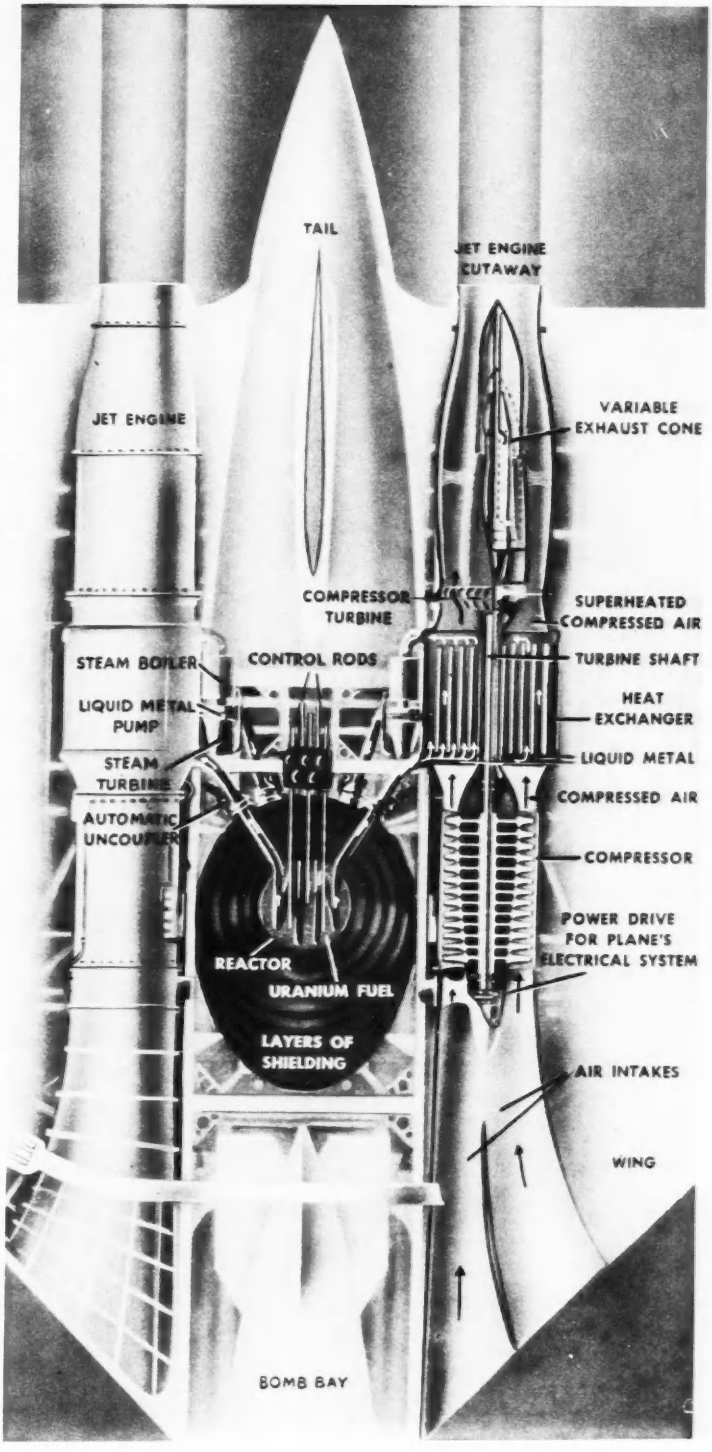
The American magazine *Life* has so far been the only journal to report on the plans being worked out by Lockheed, Rolls-Royce, and possibly other firms in Great Britain and the United States for a new aeroplane to be driven by atomic power. We are grateful to the Editor for permission to adapt their drawings of the project, as illustrated on the cover of this month's DISCOVERY and on pp. 238 and 239.

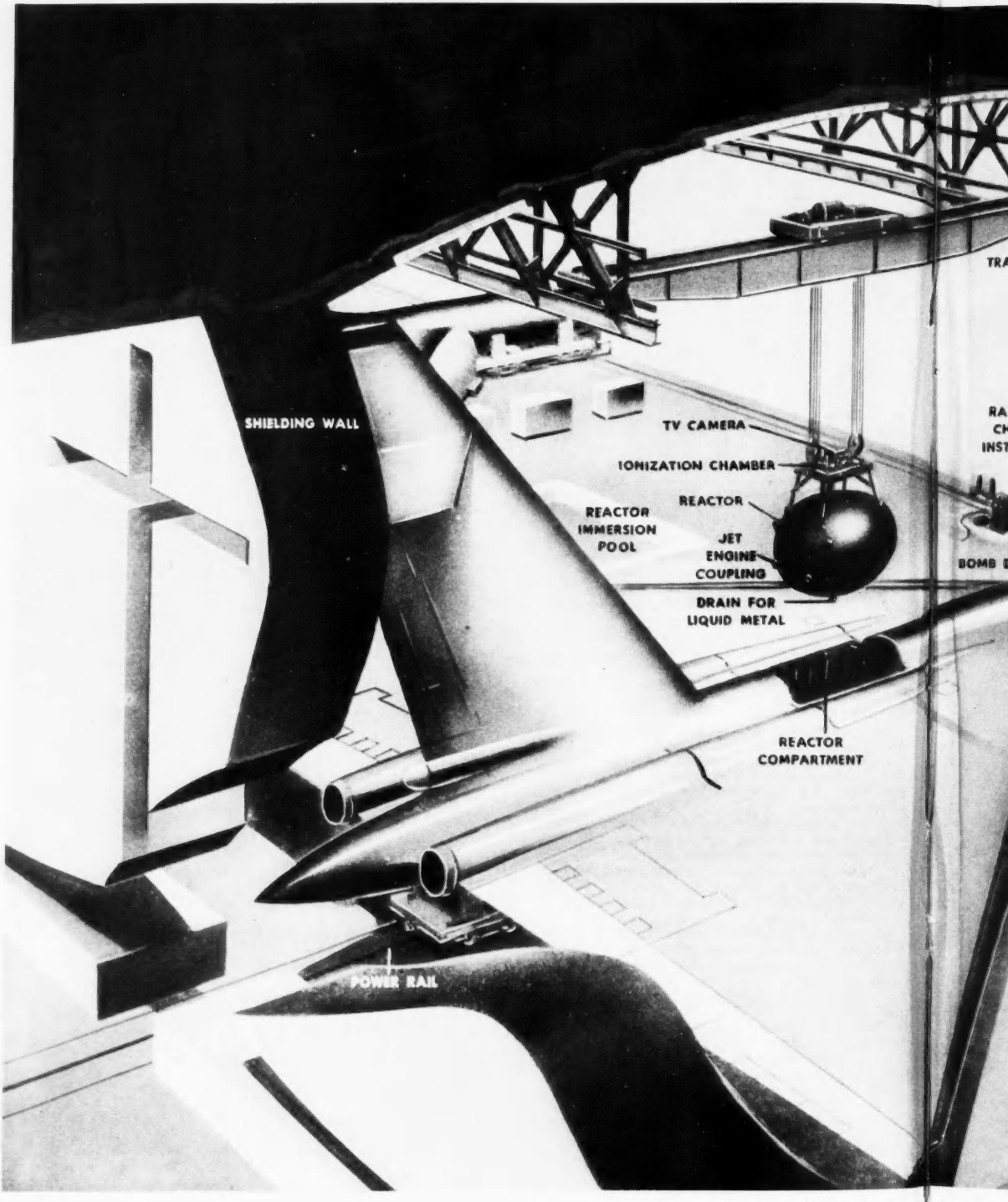
(*Right.*) The atomic power plant in the plane's tail. The reactor is placed between twin jet engines at the roots of the plane's wings. Air (dark arrows) is scooped in through vents, compressed, and then superheated in the heat exchanger, where it expands violently, blasting from the exhaust ducts and driving the plane forward. The white arrows show the flow of liquid metal heated to over 1200°F in the reactor and circulated by a steam-driven pump. The hot-air stream turns a turbine which operates the compressor and the plane's auxiliary electric generator. Speed is controlled by rods which, when thrust into the reactor, lower the temperature, and by a movable exhaust cone which varies the size of the exhaust opening and lets more air escape when greater speed is needed. The dotted line shows its position for top speed.

(*Centre spread.*) A radiation-proof hangar would be essential for servicing an atomic plane, and the drawing shows an underground chamber carved out of a hillside. The harmless nose extends into an inner chamber where maintenance men check cockpit instruments. The special "hot" chamber is protected by shielding walls. Operators keep watch through a thick viewing port and periscope, and also by means of television apparatus. A crane is seen lifting out the egg-shaped reactor from the compartment whose lid has already been removed by the same method. Ionisation chambers measure the radioactivity of the reactor, which is then immersed in the pool, where water blocks such activity. The crew can then safely enter the "hot" chamber to supervise, from behind lead shields, the underwater reloading of the reactor with uranium. The reactor is then replaced by crane, ready for another flight.

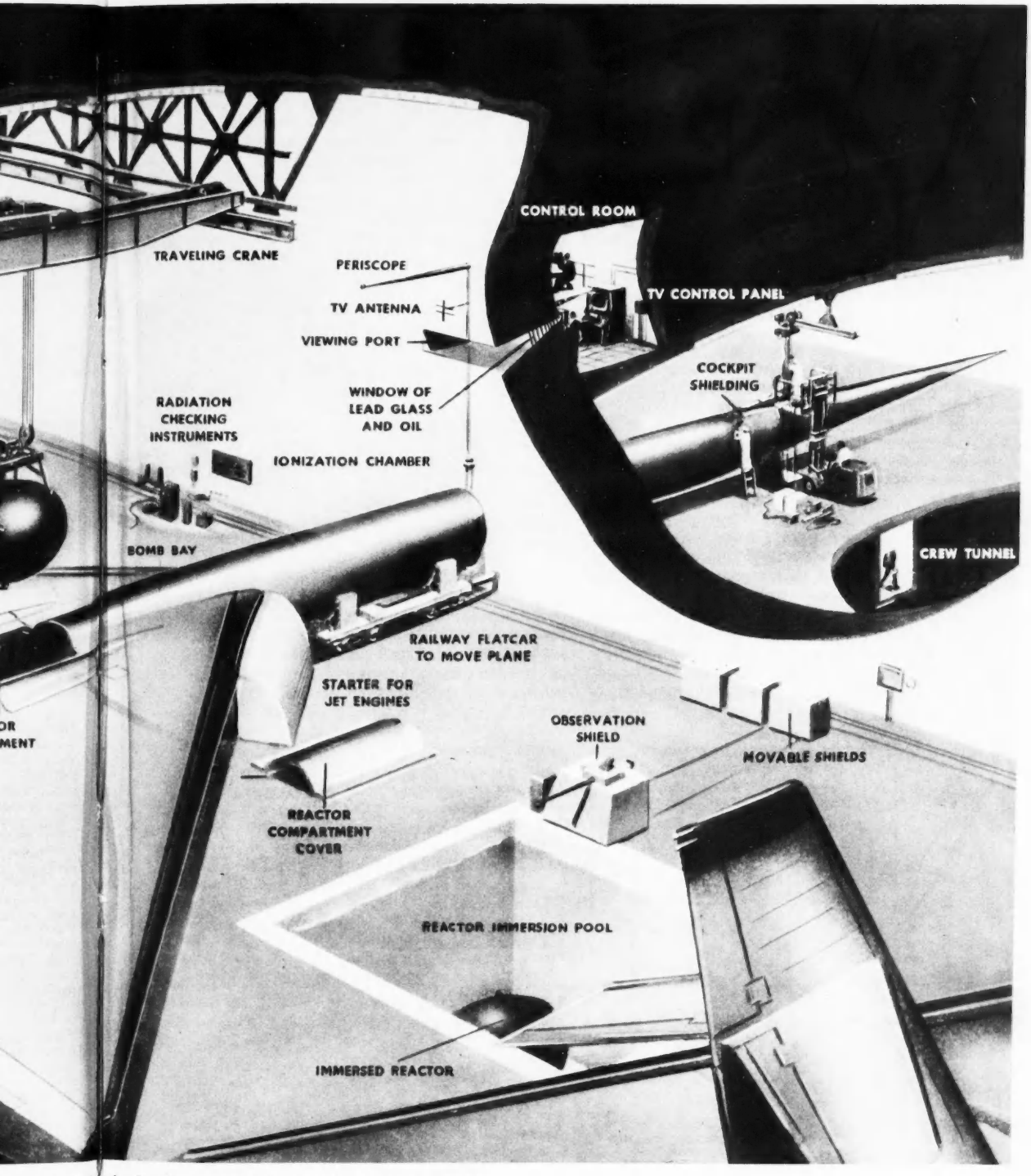
One very serious danger is inherent in the use of atomic power for aircraft. Any crash or any other mishap might produce dangerous results over very large areas. At present no precautionary measures against such accidents can be devised. This point was made recently by Sir John Cockcroft in his article in the *Financial Times* supplement on atomic energy (see DISCOVERY p. 250.)

(*Drawings by Rolf Klep*)





Sectional view of the projected atomic plane's under- and safety ha



plane's under- and safety hangar. For detailed description see p. 237.

THE EXPONENTIAL CURVE OF SCIENCE

DEREK J. PRICE, Ph.D.
Christ's College, Cambridge

Is it possible to be scientific about science itself? Can one analyse scientifically the present problems of manpower shortage, of specialisation, and of the vital part which science and technology is playing in national and international affairs? With so much at stake and with so many people involved, considerable attention should be paid to the making of any possible intelligent guesses about what is going to happen next to science "in the large". Economists can now describe and explain tendencies in the economic world, and to some extent help those whose job it is to control it. Statisticians can make similar statements about problems of the growth and change of population, but in the study of science there is no parallel. There are only *ex cathedra* statements from those eminent scientists who sense intuitively some of the problems involved. Decisions and policies are laid down by government committees and commissions who must view each case as it arises without any corpus of theory or general principle to guide them. Even in the Soviet Union, where state planning has been particularly successful in technology and science, and in the U.S.A. where these things are now major industries, there has been little attempt seriously to examine the main principles of general development of science, and to draw conclusions about the likely if not inevitable future.

Let us then examine, however crudely and approximately, anything that will tell us about the rate at which the overall size, complexity, and intensity of science is and has been growing. Since it is natural to prefer a quantitative approach, even if inexact, to any purely qualitative analysis, it is necessary to seek any data that can be obtained by a process of "head-counting" throughout a series of annual or other periods. So long as there are enough heads to count so as to secure a good statistical sample, one need not worry at first about just what is being measured, but concentrate only on obtaining a good measure.

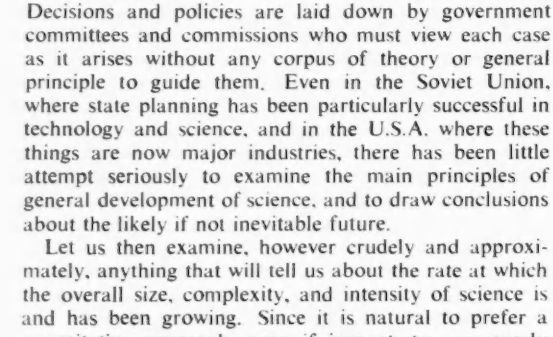


FIG. 1. Total number of *Physics Abstracts* published since Jan. 1, 1900. The full curve gives the total, and the broken curve represents the exponential approximation. Parallel curves are drawn to enable the effect of the wars to be illustrated.

HEAD-COUNTING

Convenient heads for counting may easily be selected, using national statistics, scientific publications, and figures provided by learned societies. For example one may record the number of *Physics Abstracts*, *Chemical Abstracts*, etc., in each year, so taking some sort of measure of the number of papers published in such a selective field during the period. One may prepare similar figures for an even narrower field of study by making use of any of the specialist bibliographies available. It is possible to measure manpower directly from various national statistics, professional registrars, and analyses of the output of the universities and other training institutions, and the annual expenditure in various branches of science and industry are often similarly available. Other measures may be had from the total numbers of scientific patents taken out during the year, and from sundry selective lists of "great scientists" (e.g. Dictionaries of National Biography) or notable scientific advances.

From such collections of data,* chosen capriciously for the ease of getting figures rather than for any significance in themselves, three important conclusions can be drawn:

(1) Nearly all the curves of growth show the same trends.
(2) The growth is (to a surprising accuracy, $\pm$ *ca.* 1%) exponential.
(3) The constant of the exponential curve is such as to effect a doubling in size in an interval of the order of 10–15 years.

The first conclusion seems to indicate that the data collected in fact measure, by different means, the same general phenomenon, and that it is reasonably safe to take any one of these sets of data as a provisional measure of the "size" of that sort of science. One may modify this hypothesis later, but it provides a firm foundation for a preliminary investigation (Fig. 1).

EXPONENTIAL GROWTH

The second conclusion, that of exponential growth, merely tells us something that we might have guessed beforehand—though, for some reason, planning committees seem peculiarly blind to it—the growth of most organisms tends to be directly related to their size: the bigger they get, the faster they grow. This law defines

* Price, D. J., "Quantitative Measures of the Development of Science", *Archives Internationales d'Histoire des Sciences*, 1951, vol. 14, pp. 85–93.

xponential increase and governs the growth of a colony of bacteria; it also apparently governs the size of science. Data which can be carried back to the year 1700 (or even before) indicate clearly that in general the "size" of science has been increasing in this way over the whole period since the Scientific Revolution and the time of Newton. In other words, one must assume that the *normal* state of growth in science and technology in the past and at present corresponds to a doubling in size every so many years. Any assumption that growth is linear (i.e. it will continue at the present rate) is doomed to be an under-estimate.

The last conclusion, concerning the numerical value of the time constant, is perhaps the most significant. The period of 10–15 years which characterises the growth of science is very considerably shorter than the time corresponding to a generation (say, 25–30 years) and less than that involved in exponential growths associated with non-scientific and non-technological activities of the human race. In point of fact, several other investigations suggest that the time constant for doubling in such fields is about 30–50 years, approximately three times as long at least as that for scientific activities. In a period of half a century, the number of poets, composers, politicians, etc., doubles about once, while the population of scientists doubles at least thrice, multiplying therefore by a factor of eight.

REDUCTION TO ABSURDITY

A delightful parody of these methods as applied to the growth of the Civil Service and other bodies has been published as "Parkinson's Law" (*Economist*, 1955, vol. 177, p. 635) by my erstwhile colleague and mentor in another clime. Though the burden of his argument is light-hearted he will be shocked to hear that the increase he found, about 5–6% p.a., corresponds exactly to the doubling period found for professional scientists and technologists over the last few centuries.

Those with some mathematical training do not need to be reminded of the "runaway" character of exponential growth. Ten doubling periods correspond to a multiplication in size by a factor of more than 1000, while twenty periods give a factor greater than a million. Now twenty periods each of 10–15 years give a lapse of 200–300 years—sufficient to span the interval from *ca.* A.D. 1700 to the present date. It can readily be seen that this estimate is correct in order of magnitude, for in 1700 the Scientific Revolution was just passing into the Industrial Revolution and the first few of everything had been established, whereas today, estimates of numbers of scientists, journals, etc., run into hundreds of thousands, or even millions, as the factor would predict. An exponential curve is defined by two parameters; one corresponding to the time constant already described, and a second giving the date at which the curve reaches a value of unity. Again, nearly all the curves show agreement in their date of origin, extrapolation indicating it to be *ca.* 1700–50 so far as can be seen, and this is in agreement with what has already been said.

Since the exponential growth of everything scientific is so much more rapid than that of anything in the rest of our civilisation (crude population figures included) it follows that saturation must be reached sooner or later if such growth is maintained even approximately (Fig. 2). It is important to note that a state of absurdity may be reached quite quickly, for example, a further 250 years bringing another factor of a million would give about 100 scientists for every man, woman and child in the world today! If one makes reasonable guesses as to the maximum saturation of scientists and technologists in our population, it would seem that the present law of growth would yield that value in something like 50–70 years from now. This is an astonishingly short expected lifetime for our mode of civilisation, and it is therefore worth while to make a crude estimate of the effect of saturation on exponential growth.

SATURATED GROWTH

The usual physical law associated with saturated growth shows the exponential curve modifying into an S-shaped curve approaching the maximum saturation level (Fig. 3). The "half-way house" occurs at a date corresponding to saturation on the purely exponential curve. Approximately two doubling periods before this crucial date is reached, the curve of growth begins to fall sensibly below the exponential figures. Two doubling periods after the crucial date, the growth approaches quite closely to saturation value. Returning to the present estimate it would seem that we may expect two or three decades more before the regular exponential growth will have to fall off markedly as it approaches a "turn-over" near some saturation level. This may not sound so serious, being a gradual change, but one must

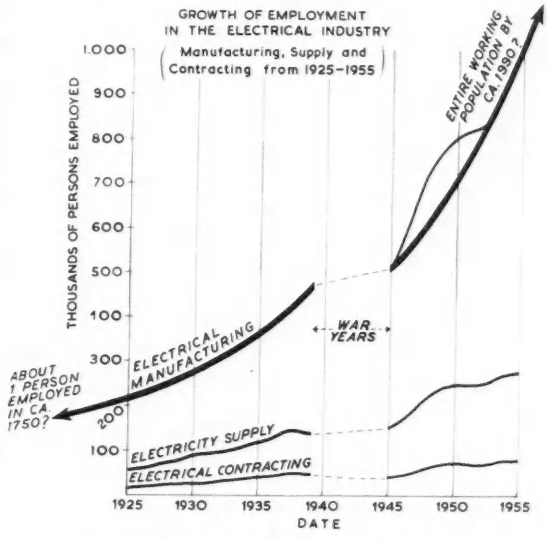


FIG. 2. Adapted from figures published by *The Manchester Guardian*, of March 20, 1956: "The Electrical Industry Today" by Dr. Willis Jackson, F.R.S.

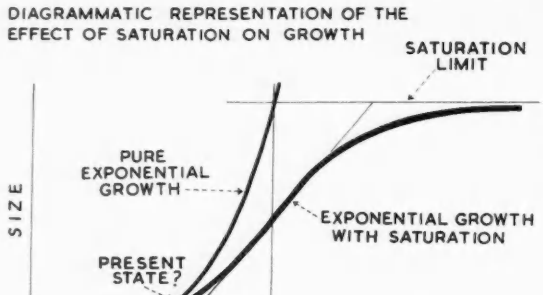


FIGURE 3

remember that normal growth has stayed with us for the last two or three centuries so that we have come to regard it as the only healthy manner of evolution. Any curtailment, however small, must react very forcibly on a national scale, having a host of side effects which are bound to be unpleasant and to inspire all conceivable palliative measures. Since the above calculations are only very approximate, giving order of magnitude values only, it may be reasonable to interpret the present manpower shortage, most apparent in a lack of science teachers, as evidence that the growth is following this general pattern and is already dangerously near its critical period. One might alleviate the growing pains by increased training facilities, change of emphasis from Arts faculties to Science, greater incentives to teachers and scientists; but these things cannot change the overall pattern, but will merely postpone the crisis for very few decades.

INTERNAL REPRESSIVE EFFECTS

The saturation process just described may be regarded as an external repressive influence in the growth of science. Other, similar analyses can be used to indicate that science carries its own internal repressive effects which seem likely to choke steady development. Every research worker today is familiar with the problem of keeping up with what is affectionately known as "the Literature". There are now so many learned journals that even the finest specialist libraries cannot take them all, and their workers can only read a very small selection of them. Even abstract journals are now becoming so unwieldy that it is already evident that some radically new technique must be evolved if publication is to continue as a useful contribution in the same sense as it was in the past. A quantitative analysis makes the mechanism of the change apparent: scientific journals increase in number as if they had started in about 1700 and doubled every 15 years (actually they started in 1665, but the first 10 years or so constitute a too small, non-statistical group). Abstract journals started about 1830 when there were already about 300 general journals in existence, and these abstract journals have been doubling in number, again every 15 years. The number of scientific journals is now approaching an order of magnitude of 100,000, and the number of abstract journals is now near the critical figure of about 300. That is why we are beginning to wonder about "abstracts of abstracts", new techniques for boiling down and analysing all the work at present being carried out.

PROBLEMS OF SPECIALISATION

A similar technique can be applied to some extent to the problems associated with specialisation and with the amount of knowledge that an intending researcher must absorb before he can reach the research front. It is not difficult to show in a general fashion that these are processes exercising a retarding effect on the growth of science, producing narrower and less flexible specialists —the process having a time constant similar to that found elsewhere in science, or perhaps (if one is optimistic) a little longer. Rather interestingly, if one attempts to measure "high-level" advances in science rather than its crude size, it seems that the growth constant is considerably larger, taking about three times as long to double. If this is true, it would mean that to double the usefulness of science involves multiplying by about eight the gross number of workers and the total expenditure of manpower and national income. It also entails the curious, though half-expected law, that the gross size of science goes up as approximately the cube of the attainment of science. To some extent this is a

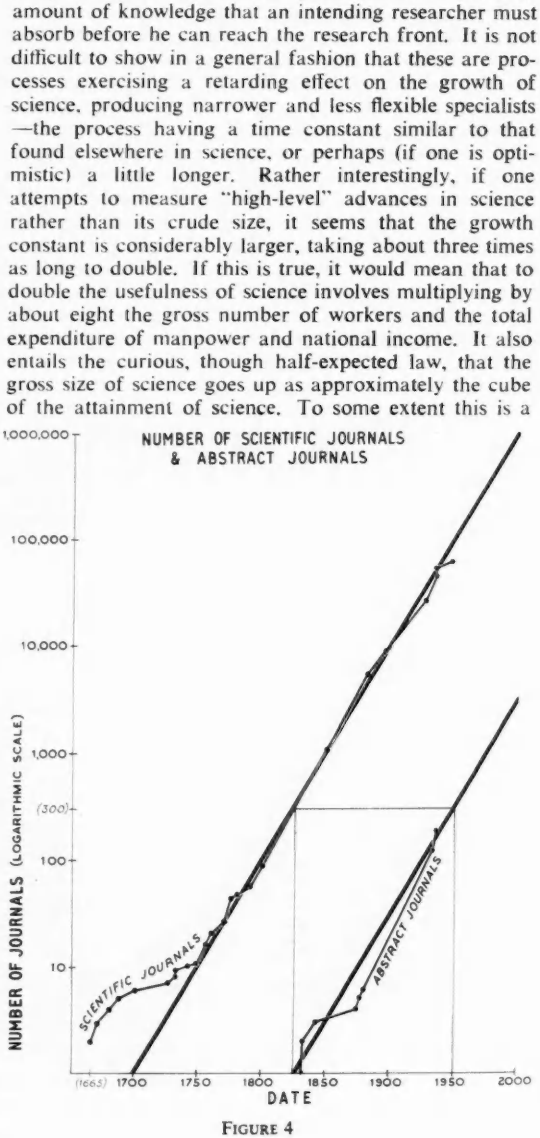


FIGURE 4

consequence of the distribution law governing the relative numbers of scientists of various degrees of excellence and inferiority. Alternatively one may regard science in the image of a pyramid of theory and experiment. The height represents the attainment, but the bulk of science must be measured by the cubic capacity of the structure.

SOME SIDE RESULTS

Other interesting side results of these investigations concern the effect of wars on the progress of science (no observable stimulus after 1938–47), and the tendency for virile, new fields just opening up to grow much faster than average until they settle down to the normal time-constant of growth. Similarly, old fields show the tendency to fall off, growing more slowly than normal. One may well use this technique to make objective judgments on the virility or sterility of certain fields of inquiry. Quite clearly there are many other ways in which this sort of analysis might provide useful information. It need not be stressed that any further investigation must also pay attention to increasing the accuracy of the very approximate statistical data already cited, and to a critical examination of the meanings of the quantities being measured. There are also many other econometric laws applicable to science in the large. It is possible to make statistical generalisations about the distribution in quality of scientific work and scientific research workers. It should be possible to develop a calculus that would tell us the optimum ratio between science teachers and scientists, and between pure scientists and technologists. Working scientists are for ever using a sort of poetic imagery which represents a subconscious attempt to get a model of science as a whole—one speaks of "the Research front" and "an isolated field" a "borderline investigation", etc., without any effort to rationalise such terms. If, as seems likely, there is indeed something in the structure of science that makes such terms reasonable, it should be possible to make such loose jargon precise in the form of theories about the general structure of science.

USE OF THE TECHNIQUE

Until there is a lot more of this sort of theory and until its limitations and advantages are better understood it is impossible to guess just how useful such techniques might be to scientists who have to organise their own researches, and to national institutions and committees who, however reluctantly, must undertake some sort of planning activity. Already, even the crude theory outlined above is sufficient to indicate that we are very near a crisis which might not otherwise be obvious until it is too late. Theory gives us the grace of a few decades in which to lay plans and to understand better what is happening during the predicted cataclysmic change in the very nature of scientific advance.

It is certainly not sufficient to utter a bald counsel of despair that we are approaching a period of saturation when there cannot be enough scientists to meet all demands, and when those scientists will tend to be stifled by their own flood of literature and intense overspecialisation. One must back up the econometric analysis by the historical analysis which it augments by an added mathematically induced perspective. One must decide what is wanted, as well as what is possible, before policy decisions can be taken. If there is saturation it follows that there must be some sort of rationing, natural or imposed, both in the internal distribution of scientists amongst their fields of inquiry and amongst the needs of the nation and industry who apply the results of scientific inquiry, all competing for the same body of manpower. At present the writing can be seen on the wall but it is no man's professional business to read it and take warning.

DEATH OF L. K. P. CRABB, O.B.E., G.M.

A correspondent writes: "In *The Times* of April 30, 1956, the death was reported of Commander L. K. P. Crabb, O.B.E., G.M., R.N.V.R. This is a severe loss to the field of underwater research, because for many years Crabb has been concerned with the development and testing of experimental diving equipment and other underwater apparatus. His courage, stamina, and imagination in World War II are well known and have been publicly recognised.

"Like H. J. Hodges, whose untimely death occurred recently in the Caribbean, Crabb was a pioneer in this country of 'free-diving' equipment using self-contained breathing sets. The development followed logically from his experience in war as a frogman. In recent years he has made many fine underwater films of considerable importance to naval problems. He quickly realised the valuable extension made possible to undersea observations by the use of television, and he was closely concerned with the development and use of the television camera which identified H.M.S. *Affray* in the English Channel. His wide experience in underwater operations and his critical intelligence provided an excellent link between the laboratory development and the final form of naval equipment.

"Those of us who have worked with Crabb have enjoyed not only his technical and operational skill, but his imaginative attitude to his visual and cine-film observations in the sea. Like J. Y. Cousteau, he saw with the eyes of an artist, and was able to record his explorations because of his technical skill. His serious approach to his work has been, and will be, an inspiration to the younger divers following him. They will use his experience to extend the horizons of this fascinating field of undersea exploration."

ASTRONOMER WITHOUT TELESCOPE

A Profile of the Astronomer Royal

Dr. Richard van der Riet Woolley
O.B.E., F.R.S.

BY A STAFF WRITER

Dr. Woolley calls himself "a lifetime public servant". This is perhaps a surprising epithet for a distinguished astronomer. But there is more truth in it than the semi-humorous tone may suggest.

It is certainly a just description of the premier astronomical post in the British Commonwealth. The Royal Greenwich Observatory comes under the Admiralty; a substantial proportion of its work is therefore devoted to maintaining two public services, the standard of time and the efficiency of the Nautical Almanac.

As for fundamental work in astronomy, Dr. Woolley has himself put the matter clearly—"no other line of human inquiry demands so great a financial outlay (since it depends on large and expensive instruments) with so little expectation of economic return". This makes the astronomer in charge of an establishment with modern instruments the guardian of a considerable amount of money to which no strings can possibly be attached. The use to which this money is put depends largely upon him.

Yet in a broader sense, Dr. Woolley's remark is applicable to his whole career in a way he may not have intended. It is a career characterised to an exceptional degree by a sense of responsibility. Because he was so able that he became Director of an important observatory at thirty-three, he could have occupied himself exclusively with research for the rest of his working days. Instead he has come out of the sanctuary of observatory and university and done battle for his science in the public arena. And this has not been at the expense of his main work in astrophysics. He has made very considerable advances in the fundamental study of the mechanical properties of stars (with which his work on the Sun is of course closely related), and he has published the results of his work extensively.

In particular his sense of duty takes the following forms: he has shown a responsibility for improving the status and value of studies in astronomy—and especially within the British Commonwealth taken in its broadest sense; he has revealed a strong identification of interest with the aspirations and potentialities of Australia and her universities where he was for so long; he is deeply aware of the obligation (to other scientists) to publish—and of the rights of the general public to know—what is going on in even the most abstruse branches of learning.

With these various obligations heavy upon him, perhaps he feels his most pressing duty now is to Time. . . . With only one man's span in which to fulfil so many demands and to pluck out some significant truth from the vast riddle of the universe, he is urged above all by the need "to get on with it".

EDUCATIONAL BACKGROUND

It may be supposed that Dr. Woolley's upbringing played some part in forming his attitudes. He was born in 1906 at Weymouth. His father was a Paymaster-Rear-Admiral and a C.M.G.

He was educated at All-Hallows School, Honiton,

and at the University of Cape Town where he took an M.Sc. He went up to Gonville and Caius Cambridge in 1926 and took his mathematical tripos in 1928. In 1929 he won a Commonwealth Fund Fellowship to the Mount Wilson Observatory in California, which already possessed the largest telescope in the world, at that time the 100-inch. He worked there for two years before becoming Isaac Newton Student at Cambridge. These two further years at Cambridge ended with his being appointed Chief Assistant at the Royal Observatory, the post immediately below that of the Astronomer Royal: he was then only 27. The fruit of his first four years at Greenwich was the important book "Eclipses of the Sun and Moon", one of the International Series of Monographs on Physics, written in collaboration with Sir Frank Dyson, who had recently retired from his post as Astronomer Royal. The book was published in 1937.

While Isaac Newton Student, Dr. Woolley met and married Miss Meyler from Girton, a graduate in English. In 1937 the Woolleys left Greenwich and returned to Cambridge where, at 31, Dr. Woolley was appointed John Couch Adams Astronomer. Two years later, the year war broke out, he became Commonwealth Astronomer with his headquarters at the Commonwealth Observatory at Mount Stromlo, Canberra, Australia.

He remained there for sixteen years in all, until he took up his appointment as Astronomer Royal on January 1 of this year. His second contribution to the International Monographs on Physics and the book that most scientists would agree with him in thinking his most important work, "The Outer Layers of a Star",* was finished shortly after completing his decade in Australia. Before uprooting in order to take up his new post, Dr. Woolley had a bare four months testing the newly completed 74-inch reflector telescope at Mount Stromlo. This is now the largest in the British Commonwealth and it is entirely due to him that it was erected in Australia. It is perhaps superfluous to add that the instrument would have proved of great value in Dr. Woolley's personal researches as he had for many years planned an attack on the Southern stars.

ASTRONOMER ROYAL

In a number of ways the appointment as Astronomer Royal must be considered a setback in this career.

From Mt. Stromlo in Australia, Dr. Woolley had magnificent conditions from which to observe the less well documented Southern constellations, and he had just gained a worthy instrument with which to do this. Furthermore to help him he could draw on a great deal of research money and a considerable group of ambitious young men trained by himself—both features of the recently founded Australian National University, Canberra, a postgraduate institute in which Dr. Woolley held the post of (Honorary) Professor of Astronomy and where he conferred the first degree.

At Herstmonceux he is inevitably saddled with many routine and some awkward administrative decisions, and a number of irrelevant scientific chores. No provision is at present made at the establishment for teaching—a task close to Dr. Woolley's heart. But by far the most serious drawback of the Observatory to a research astronomer is its present total lack of a working telescope. This is due to a concatenation of unfortunate circumstances: it is nevertheless a situation that has in effect persisted for sixteen years. One or two equatorial telescopes did operate at Greenwich after the war; but even these are now in packing-cases and the most optimistic estimate gives August as the earliest date on which any telescope will be ready for use. The Isaac Newton 100-inch is not promised under seven years, which probably means ten years in fact. It is perhaps not surprising that the Greenwich staff of astronomers is somewhat lacking in observing experience, but it is more serious that the prospect of attracting very able young men and women there is not good either—as a result of the decay in astronomical studies at the universities. (This of course affects other British astronomical institutions besides Greenwich.)

Some of these things may be changed or remedied, and Dr. Woolley is likely to be the man to do it, but such changes do not occur overnight.

It is in this context that one must interpret the Astronomer Royal's painful statement that "no spectacular success has ever fallen my way". This statement, coupled with the present Herstmonceux situation, gives meaning to the electric urgency of Dr. Woolley's voice when he speaks of his plans for astro-physical work at the Observatory.

A typical astrophysical problem is presented by current theories of star formation. There is a growing body of evidence—much of it from the United States—which suggests that some of the stars are a mere 1,000,000 years instead of 10^{10} years old, the age traditionally ascribed to the universe. The evidence for or against the newer ideas must be painfully won by observation and carefully sifted. Some of the work which is planned at the Royal Greenwich Observatory is designed to contribute ammunition for this crucial controversy.

"THE LONGEST TYRANNY"

In an excellent little introductory book on astronomy, published when he was at Greenwich as Chief Assistant, Dr. Woolley wrote that "for an elderly observatory Greenwich holds its head high among the astronomical centres of the world"; he also described the United States as "the great stronghold of scientific astronomical observation". Twenty years later the second point could well be put more strongly—and the first would be tough to support. Dr. Woolley wishes it otherwise—indeed has been "campaigning"—there is no other word—with the considerable wit and extensive historical scholarship he commands, for a reversal of the present system of astronomical education, which mostly consists in leaving astronomers somehow to find out about their science after they have formed an Observatory staff.

* Written in collaboration with D. W. N. Stibbs and published in 1953.

Here is the opening of his Inaugural Lecture as Professor of Astronomy at the Australian National University delivered in July 1955. With the title "The Longest Tyranny" (a quotation from Dryden*) it traced the obfuscation which Aristotelian science had upon European thought and how observational astronomy released the other sciences and ushered in the Age of Reason.

"It is the purpose of this lecture to give an account of the longest tyranny, and of its overthrow. It is an appropriate subject for the Inaugural Lecture of your Professor of Astronomy, because astronomy was subject to the tyranny, and more so because astronomy played a very large part in the overthrow. At the end of the lecture I shall come, shall I say, to earth, with a short view of the teaching of astronomy in British universities, whose meanness I contrast with the grandeur of the history of astronomy in relation to human thought; the whole of my lecture is meant to argue that astronomy, which has had so prominent a part in the development of our scientific ideas, ought not to receive such scant attention as it does now receive in our teaching programmes."

Then, to the peroration: ". . . I turn now from these splendours to the melancholy spectacle presented by the actual state of astronomy as a teaching subject in British universities. It is practically not taught at all."

"There is still an astronomical profession. Our older universities have observatories, built when astronomy was still the only observing science conducted on a large scale. Some of these have been modernised. There are still several chairs of Astronomy in England, but there has been of late a tendency to appoint professors whose main interests are not strictly astronomical. The truth is that there is a desperate shortage of genuine astronomers to fill them, and this, though due in part no doubt to the great proliferation of the branches of mathematical physics and to the great competition for graduates, is surely due for the most part to the simple fact that astronomy has been crowded out of the undergraduate curriculum. Nothing is more destructive to the interest taken by undergraduates in a branch of knowledge than having no examination questions set in it."

This is a fair sample of his style—manly yet not unsubtle, touched on every page with an ironic yet genial humour, ringing with the authentic rhythms of the great days of English prose. Is it fanciful to find something here of the thrust of Dryden's essays?—some of the neatness of Addison?—to detect an occasional Miltonic flight?

Dr. Woolley certainly has the equipment and the flair for simplification that makes the good "interpreter" of science to a wider public. Such an interpreter would be an asset to astro-physics. The lack of general understanding of this science must contribute to the absence of learned interest of which he complains.

Though the new Astronomer Royal has in only six months acquired a reputation for catching the headlines, his own reaction has been one of dismay—dismay at the way his asides (for that is what they were) have been blown up and bandied round without hint of the context in which they were spoken. He has resented the distractions this generated. Until now he has resisted attempts to be turned into a television personality. But it might be no bad thing if he could do for stars what Peter Scott has done for birds and his namesake Woolley has done for what many people used to think of as "old pots".

THE MAN HIMSELF

And what is Dr. Woolley like to meet?

The new Astronomer Royal is a big man, lean, active-looking; with an "outback" handgrip and a piercing yet merry glance set in a strong, tanned face. Australia has marked him—by the tan and, very slightly, by her speech. His manners are informal and direct, yet expressive. He speaks his mind out to anyone who asks. The impression this leaves is that he has formed his opinion, in fifty years, on most things, and if he is to give his view he will say his piece without fear or favour . . . Also that he will give the same consideration to the other man's views.

His expression is transformed with amazing rapidity from a stern, uncompromising look that may suggest anything from (to use a cliché) the face of the man on the bridge of a battleship to an engaging grin that warms the room. His talk swings in a similar unexpected way: he will switch from mention of "the troops having organised some tennis for this evening" to a pithy statement, almost aphoristic in quality, on astrophysics in the next ten years.

On the walls of his study on the eastern, lake side of Herstmonceux Castle, hang at present two pictures. A delicate contemporary silhouette-portrait of Caroline Herschel and a mounted cutting of Giles' cartoon from the *Express* of marching space-men bearing placards—"Woolley Unfair to Space Men!"

He likes—and notices—people and things outside his own science. For instance he talks most illuminatingly about the rate of progress in routing Victorianism here and in Australia. It is interesting that he finds Britain has freed herself more completely than the United States —though less than Australia. "But in the past sixteen years England has become very Australianised!"

Dr. Woolley's appointment to Herstmonceux will probably be a setback to his own astrophysical researches, but it must be heartily welcomed by the Observatory itself and by British astronomers generally. A man with his stature and practical drive in getting things done, a man with such a wide and sympathetic knowledge of affairs in the young countries abroad will be a tremendous influence on scientific affairs at this point in our history.

* "The longest tyranny that ever sway'd,
Was that wherein our ancestors betrayed
Their free-born *Reason* to the *Stagirite*,
And made his torch their universal Light."

"To my Honour'd Friend Dr. Charleton, on his learned and useful Works."

THE INTERNATIONAL GEOPHYSICAL YEAR

MONTH BY MONTH

Last month the Antarctic was well in the front of IGY news. Now this region has dropped back, with the end of the 1955–6 "season"—save only for the Australians' report, the arrival of which shows the time-lag one would expect. Instead of unity then, there is diversity—reports of many different types of research, with a variety of objects, from a number of scattered parts of the world.

Planning

The period of the IGY was selected so as to coincide with one of the eleven-year peaks in sunspot activity, and there is some evidence that the coming maximum will be the greatest ever known. The Sun is intimately connected with five out of the fifteen departments into which IGY work is grouped—that is, with meteorology, geomagnetism, the aurora and airglow, and ionospheric work, as well as with the solar and cosmic ray programmes.

Plotting present sunspot activity against the time scale, it appears likely that the maximum activity will reach a climax sooner than expected. This graph might mean either that the total sunspot activity will by far exceed anything known to have occurred in the past, or that the maximum has shifted to an earlier date than was originally foreseen. In either case it should provide excellent opportunities during the International Geophysical Year for world-wide study of solar activity.

Latest estimates give February 1957 as the likely month of sunspot climax. This means that to take full advantage of the unparalleled opportunities for simultaneous, world-wide observation and communication, those programmes most closely linked with solar activity must be hurried forward. The various complex and bulky instruments that are now being built in the main scientific centres must somehow be got ready in time to be shipped and set up in the jungles, on the tops of mountains and amid the world's wastes, key positions in the network, from which records have never been obtained before. It gives some insight into the organisational problems facing national committees to learn for instance that it takes nine months for one ton of instruments to travel from Britain to a given destination inland on the equatorial belt of Africa. However, there seems plenty of confidence that the race may be won by scientists.

* * *

The provisional date for the Antarctic conference in Paris is announced. Here, all the nations taking part in this programme will report, and give news of the advance bases set up during the Antarctic season which has just finished. The conference will be from June 11 to 14. This is the third conference of the Antarctic Working Group.

* * *

At the end of March, CSAGI (the central organising body) published the symbol to be used in connexion with IGY activities. By the kind permission of the Secretary-General, Prof. M. Nicolet, DISCOVERY can incorporate this symbol into the heading of each monthly report. It appears this month for the first time.

* * *

The British National Committee has recently set up a small panel to deal with the problem of the processing and duplication of British observations. Among the points under consideration is the value of using electronic digital computors. These should be especially convenient for processing ionospheric measurements.

The fifteen sections into which IGY activities are grouped are:

I World Days
II Meteorology
III Geomagnetism
IV Aurora and Airglow
V Ionosphere
VI Solar Activity
VII Cosmic Rays
VIII Longitudes and Latitudes
IX Glaciology
X Oceanography
XI Rockets
XII Seismology
XIII Gravity
XIV Geographical Distribution
XV Publications

Australians Justly Proud

Mr. Menzies, Prime Minister of Australia, recently announced that the Government has granted more than £A67,000 to the Commonwealth universities for IGY projects. Nor does this complete Australia's participation, financial or otherwise. The Antarctic exploration, both on the Commonwealth's own account and that in collaboration with Great Britain and New Zealand lie outside the universities' grant, and there are other additional projects in hand.

The universities' IGY programmes include upper-atmosphere work and studies of ocean tides. Investigation of the earth's interior is also scheduled, and details of this programme must be awaited with eagerness, because so far more has been heard of work to extend our knowledge outwards from the earth's crust than inwards. The Australian Academy of Science will administer the grant to the universities.

In making the announcement about Australia's IGY participation, Mr. Menzies said: "It is fitting that Australia should play a significant part in the programme. In the first place, Australia is a key country on account of its geographical position and extensive territorial interests. Secondly, Australian scientists have achieved a world-wide reputation in the study of the upper atmosphere, radio-physics and such subjects."

Mr. Phillip Law, Director of Australia's Antarctic Expedition, back from Antarctica in the polar ship *Kista Dan*, was accompanied by Mr. Bechervaise, the leader of the 1955 Mawson main-base party. "World interest is now focused on the Antarctic," said Mr. Law. At the present time Australia can boast the best-equipped scientific observatory in Antarctica, and, for the first part of 1956, Mawson was the only settlement on that continent. Since then, of course, Britain, the U.S.A., France, Russia, and other countries have "thrown vast resources into unfolding its secrets".

The Russian base at Mirny is 800 miles from Mawson. On the two-day visit made by the Australian party cruising in the *Kista Dan* to Mirny, the Russians showed a commendable spirit of co-operation, said Mr. Law. They were frank about their plans and told of an ambitious project to build two bases in the heart of Antarctica entirely by airlift. They already had a highly efficient station at Mirny.

The *Kista Dan* spent three months on exploration along the Antarctic coast, in addition to taking a relief party and supplies to Mawson. Aircraft from the ship had photographed 1000 miles of the Wilkes Land coast. Continuous depth-soundings were made as the ship

FIG. 1. Mount Kenya looking south-west down Lewis Glacier into the Teleki Valley in which the Naro Moru River flows. To the left of the rough ice is the Curling Pond. The peak to the right is Point John. (*Crown copyright*).

cruised through waters never visited before, and valuable scientific information was gathered during the numerous landings.

The first aircraft hangar to be built in the Antarctic has been completed by the expedition at Australia's permanent base, Mawson. The all-steel hangar was completed under appalling conditions. Hampered by heavy clothing, the men crawled tirelessly over the girder framework to clamp on the roofing sheets. At one stage they worked under the buffeting of a 65-mile-an-hour gale, and with temperatures 20 degrees below freezing.

The Mawson party has two aircraft, an Auster and a Beaver. The Auster has already been used for an aerial photography survey of the terrain some 60 miles from Mawson, and a detailed survey of the coastline over 100 miles to the west.

During the year the RAAF flight operating from Mawson plans to complete an aerial survey of some 10,000 square miles of Australia's Antarctic Territory.

British East Africa's Vigorous Programme

Prof. J. P. Andrews of the Physics department of Makerere College, Uganda, and corresponding member of the British East Africa committee which met for the first time on March 26, arrived in London at the end of April. DISCOVERY had the opportunity to discuss with him the observations planned in British East Africa for this highly significant equatorial area. The programme has been initiated by scientists out there and is to be entirely financed from the small funds at the disposal of the three territories, Kenya, Uganda, and Tanganyika. The one exception to this is the £4000 put at their disposal by the Royal Society for a cosmic ray apparatus.

"Makerere will then have the monopoly of cosmic rays in equatorial Africa!" said Prof. Andrews. The apparatus, which will measure meson and neutron flux, is of internationally-agreed design. Parts will be obtained in Great Britain and the apparatus be erected at Makerere under the supervision of Dr. D. M. Thomson of Makerere. Because of the heavy lead shielding this apparatus weighs about 5 tons. The usual time required to transport a freight of this description is nine months. This would mean the apparatus would not be available at the crucial period of increased sunspot activity next spring. It is therefore hoped that a fast vessel, perhaps naval, may be found to "rush" the instrument out to East Africa.

Few observations have ever been made of cosmic radiation at the equator, where there is very little activity. Is there any? If means can be found to erect the apparatus at Makerere by Christmas Dr. Thomson intends to find out.

Another striking section of the programme relates to the key matter of equatorial glaciers. It is now generally accepted among glaciologists that the more accessible glaciers have been on the whole in retreat for the past seventy years. At this rate the rise in sea-level is about 4 inches per century—not too serious.

Little, however, is known of equatorial glaciers; indeed, some people maintain they are advancing. Until a total picture of world glaciological "movement" has been obtained no sound causal relationship, for instance, with solar radiation or atmospheric transmission, can be made.

East Africa is well endowed with glaciers. The highest mountain in

FIG. 2. Mount Kenya's twin peaks, Batian (*left*) and Nelian (*right*) from the south, showing, on the left, the great west ridge below which is Tyndall Glacier. On the south face hanging between Batian and Nelion is the dagger-shaped Diamond Glacier, below which is a small portion of Darwin Glacier. In the centre of the photograph, immediately below Batian, is Midget Peak, and to its right is Point John. On the right is the mile-long Lewis Glacier topped by Point Lenana. In the right foreground is Castle Rock. All the glaciers drain into the Teleki Valley to form the Naro Moru River. (*Crown copyright*)

Africa. Mt. Kilimanjaro (19,340 feet) in Tanganyika, possesses some most interesting residual ice-masses actually within the crater of the extinct volcano. Moreover Kilimanjaro is only 8 miles from the equator. In 1953 Sheffield University mounted a geological expedition to this location which was not able to finish its work in one season. The East African IGY group are hoping there may be a second expedition from Sheffield to complete the glaciological study of Kilimanjaro.

Ruwenzori, the area often known as the "Mountains of the Moon" also possesses glaciers. Here the IGY committee hope to get some help from the Uganda Mountain Club which under the presidency of Mr. Cartland has already placed marks on the Ruwenzori ice. The region, though not so high as Kilimanjaro, is extremely inaccessible, being some days' journey from the nearest possible base.

A third source of glaciers is Mt. Kenya, until lately right in the Mau Mau area. Prof. Andrews is confident that his group will tackle Mt. Kenya too.

Seismology is of especial interest in this region. The area bordering the Rift Valley is highly volcanic and earth tremors are frequent throughout East Africa. Government geological surveys are likely to lead this work, but the need is for more seismographs. At present there is only one in British East Africa although over the border in the Belgian Congo there are at least three. This is particularly tantalising since, due to the form of Belgian colonial structure, no provision is made at present for scientific co-operation across neighbouring frontiers. To get an adequate seismological coverage for the three colonies, Prof. Andrews considers five seismographs are necessary. His committee were unanimous in urging that this opportunity to set up a permanent seismological network should be taken.

A substantial meteorological programme is also planned. An important contribution here will be on atmospherics. It is hoped to set up three direction-finding stations probably at Entebbe, Nairobi, and Tabora, in order to "position" the origin of atmospherics. The necessary apparatus for this study has already been obtained.

New Zealanders to Buy MV *Pretext*?

The *John Biscoe* has completed her last voyage as a Royal Research Ship attached to the Falkland Islands Dependencies Survey, and is now on her way home. As a new and larger *John Biscoe* is to take her place and is now under construction, the original ship has been renamed the *Pretext*. She may soon be on her way back to the Antarctic. The Ross Sea Committee of the Trans-Antarctic Expedition are negotiating for her purchase, though at the time of going to press the sale was not complete. If the New Zealanders buy her she will be used to transport the party leaving for McMurdo Sound (Antarctica) this coming December.

FIG. 3. R.R.S. *John Biscoe* (now M.V. *Pretext*) leaving FIDS Base A at Port Lochroy. Mount William (5250 ft.) on Anvers Island, is seen in the background. (*Photo: FIDS*)

The MV *Pretext* of 890 tons was originally a wartime boom-netlayer, but she has been much improved for her polar work in the Antarctic where she has served for nine years. She was expected to reach this country from the Antarctic towards the end of May.

Arctic Drifters

The men who are to man the new Russian Arctic drifting station, "North-Pole-6", left for the Central Arctic from Leningrad at the end of March. They are setting up the new station where "North-Pole-2" ended its drift in 1951.

In the middle of April the reliefs for "North-Pole-4" and "North-Pole-5" drifting stations arrived and took over from the previous crews.

Denmark and Greenland

A full account of Danish participation in the IGY has just reached DISCOVERY. The extensive programme planned for the geographically unique Greenland area is of outstanding interest. We give this month only a summary of the main proposals.

The two seismic stations already established on each coast of the country will be expanded and microseismic readings added to the day-and-night observations already being made. A further station, "Station 0", is to be established in the northernmost part of Greenland, at about latitude 81° 36′ N. to observe the very small tremors characteristic of this region. When established "Station 0" will be the most northerly seismic station in the world.

Denmark is already operating so many meteorological stations that there is no call for more; however, the work at the existing ones will be expanded. In particular a third, temporary, geomagnetic station will be inaugurated at Julianehaab on the south-west tip of Greenland; and a number of meteorological stations are to have all-sky cameras for auroral work. Visual observations of auroral phenomena will be made in addition by all the small weather stations.

Greenland's position just north of the "auroral belt" makes ionospheric recording in this area of special, indeed critical, importance. A close study of the relationship between auroral activity and radio-wave echoes is to be made at Godthaab (East coast), where the most modern ionospheric recorder will be working side by side with an all-sky camera. Special measurements will be made evening and morning when the layers of the ionosphere are varying extraordinarily rapidly. Are sudden ionospheric variations world-wide?—or characteristic of large areas of the earth?—or are they strictly local phenomena?—these are the questions.

The absorption of cosmic "noise" by the ionosphere is also to be a major study. A special apparatus is to be erected at Godthaab which will register cosmic "noise" continuously at the 30 to 33 Mc/s. range. At this frequency cosmic "noise" is nearly equal in all directions in the sky. Vertical soundings should yield information of how much the rays are absorbed in their passage through the ionosphere. This job is to be carried out in co-operation with the Swedish and Soviet national committees and also with the Geophysical Institute at College, Alaska.

Two sets of measurements are to be made in Greenland of atmospherics. This is being done in conjunction with Great Britain's DSIR, leaders in this field. At Angmagssalik, on the East coast, latitude 66°, measurements will be made between 15 and 250 kc/s. on equipment specially designed by DSIR. For some time now the Danes have been making measurements on the 1–25 mc/s. range both at Angmagssalik and Narssaq, but at this wavelength the level of atmospherics is very, very low —indeed extremely hard to detect. The suggestion has been made that perhaps our troubles from atmospherics come from disturbances in the tropics. With the new wavelength experiments, there

should be some significant evidence on this point.

A comprehensive study of glaciology is planned. This falls into two sections: work along the coastal strip and study of the inland icecap.

On the West coast three stations are to be erected: one in the "high Arctic climate" area, near Thule, 76° 30'; one about half-way down the West coast, on Disko Bay, and one in South Greenland. Two more are to be set up in the East and North-east of the country—one near Angmagssalik (66°) and the other on the island of Clavering close to the 74° parallel; there may even be a third on this coast.

All these stations will make detailed maps to show changes of glacier shape over a number of years, as well as recording the present glacial topography, and these will be related to climatic changes over the same period. Other observations, including measurements of snowfall and melting, will also be made.

Study of the inland ice is a much more difficult and costly undertaking. Denmark felt she could not bear the cost of such an expedition alone and therefore sought international help. An International Glaciological Expedition to the Inland Ice, with the French polar explorer, Paul-Emile Victor, as leader, has now been planned. However, the preparations for this must be on such a scale and will take so long, that it will not be possible for the expedition to be in position during the IGY period. It is expected that it will take place in 1959.

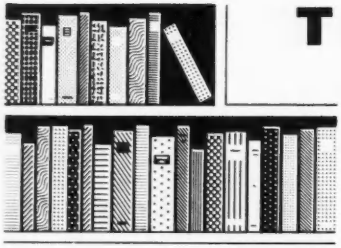
In oceanography a substantial programme is also envisaged by the Danes. A large number of ships and shore-stations will co-ordinate observations in order to make a thorough study of the North Atlantic; in particular, the Davis Strait, Denmark Strait, and the Arctic Sea. This operation is intended to provide the material to draw up a complete oceanographic map of these waters, showing in detail, temperature, salinity, currents, and so forth. Besides this work there will also be a concentrated study of the sea during two prescribed periods, summer and winter 1958, and this should yield comparisons of far-reaching importance. Work will be carried out in co-operation with Canada, France, Great Britain, Germany, Holland, Iceland, Norway, the Soviet Union, Spain, and the U.S.A. Denmark's sphere of study will lie on a line through the Shetlands, via the Faroes to the waters round the south of Greenland to the Davis Strait, between Greenland and Baffin Land.

Hungary and the Ionosphere

Hungary has decided to participate in the IGY, and a national committee has been formed of representatives of every branch of science.

A systematic study of the ionosphere will be her main contribution. Her scientists will try to establish the laws of air movement in the upper atmosphere. Hungary's programme includes radio soundings of the ionospheric layers, study of the effect of the Sun on the upper-air strata and the measurement of winds in the ionosphere.

Special instruments are being made for these observations.



THE BOOKSHELF

Atomic Energy

(A Financial Times Survey, London, 1956, 4d.)

The *Financial Times* has performed a great service for all those interested in nuclear engineering in providing in a very cheap form authoritative information about prospects for the large-scale use of nuclear energy. It must be read in conjuction with the Government's White Paper on nuclear power which was published about a year ago. Very interesting information about the probable cost of nuclear power is given in articles by Mr. Hill and Dr. Arms. The White Paper predicted a price of about 0·6*d.* per kW. at 80% load factor, but the information was rather unsatisfactory since the price at which the by-product plutonium had been costed was not stated. This is now given as £10,000 per kg., the price at which the U.S.A. is prepared to sell U235 in enriched form. Dr. Arms quotes a re-estimate by Pask and Duckworth (of the CEA) of the cost of power. The result (for a 75% load factor) is 0·7–0·9*d.* per unit, without any allowance for plutonium and 0·43–0·65*d.* with such an allowance. This is compared with a price of 0·52*d.* for a modern coal-fired station working at the same load-factor. Of course the average cost of power, at the average load factor of about 50%, is considerably higher, probably about 0·67*d.* The capital costs of the present Calder plant are given by Hill as about £240 per installed kW. without locked-up uranium, or, adding £5 million for the fuel invested, about £300 per installed kW. at the rated figure of 70 mW. per station. But of course the Calder plant is not optimised for power production since it is being built as a combined producer of power and plutonium for military purposes. Hill estimates the capital costs of a CEA station of improved Calder Hall type as £123 and £160 per kW. with and without invested uranium. The higher of these costs, though more than 2½ times greater than for a modern coal-fired station, is clearly by no means prohibitive in view of the low fuel costs of nuclear plants which may be zero (or perhaps could be even negative) when due allowance is made for the plutonium. Thus it would seem that the improved Calder type of plant, besides being a pioneer, is certain to be nearly if not quite economic, and undoubtedly cheaper than conventional plant using imported coal or oil fuel. I think there is no doubt that our gas-cooled type of plant is leading the world by a long way in the production of economic nuclear power. At the same time, it is not difficult to see its Achilles heel. This is the £5 million investment of uranium in each plant, which means that it has what the Americans call a "low materials efficiency". This not only adds appreciably to the cost; it also means that on account of the short-term limitation of uranium refining plants (as well as possibly of ore supplies) there might be a ceiling on the rate at which our power programme could be expanded. So plants with better material efficiency and also with higher thermodynamic efficiency will have to be developed for the later stages of the CEA programme. It is reasonable to hope that substantial reductions in capital costs can be made along these lines. In any case we as a nation can congratulate ourselves for an excellent start.

The articles do not contain very much technical information about nuclear reactors. In this respect the reader may be advised to supplement his information by reading vol. 3 of the "Peaceful Uses of Atomic Energy" (report of last summer's Geneva Conference). But Sir Christopher Hinton gives an interesting account of the engineering problems of the Calder Hall reactors. There are also articles by members of the industrial groups engaged in design work for the CEA programme. In one of these, Mr. Millar gives a warning that our present British programme is geared to large-scale power units, and that the U.S.A. (whose small "packaged" reactor is elsewhere stated as due for operation for the U.S. Army at the end of 1957) is considerably further ahead than we are in the development of small units of say 5–15 mW., which might form an acceptable export. Though at present costs are almost certainly too high except for very special purposes, there is an obvious line of development here. Incidentally, a very useful diagram is

provided to illustrate the various possible types of reactor.

In an extremely interesting article, Mr. Bowie of the Geological Survey gives the facts at present known about potential uranium (and thorium) supplies. Briefly it can be stated that there seems to be (outside the U.S.S.R.) about 1 million tons of uranium available in high-grade and medium-grade ores (but including the low-grade Rand ores). Elsewhere the price has been estimated at about £4 per ton, and there are in addition 10 million tons available in medium-grade shales, phosphate rocks, etc. (at a somewhat higher price). In addition, of course, there are enormous reserves in low-grade ores. If the 11 million tons could be used at 100% efficiency, they would be equivalent to the total present world usage of coal and oil for 2000 years.

Of course such full utilisation is impossible. It is generally accepted that at the present time a burn-up of ½% should be possible before chemical reprocessing. (Sir John Cockcroft's reference to this matter has a misleading misprint, the word per cent having been omitted!) A total utilisation of only a few per cent (without taking into account the 25–30% thermodynamic efficiency of the system) seems all that can be expected until "breeder" reactors come into operation. But then it may be hoped that a much greater utilisation, perhaps 30%, will become feasible. Perhaps rather oddly, there is hardly any information about the Dounreay experiment. There are several articles about nuclear energy materials, but not much about the work which has to be done to improve the properties of materials subjected to radiation and in making fuels which are resistant to damage caused by the fission products formed inside them. This type of research work has an obvious bearing on the ½% burn-up already referred to, and it is satisfactory to know that we will soon have the high-flux research reactors for the job. Another omission is that problems of chemical re-processing, very important from an economic point of view, are not referred to.

Sir John Cockcroft and Dr. Dunworth provide brief discussions about possible long-term uses of nuclear energy. They both discuss among other things the application of nuclear energy to transport. Interesting details about the performance of *Nautilus* are given by a U.S. correspondent. These articles do not lead to much faith in nuclear transport, except for military purposes, though use in merchant ships may come if costs can be got down. I found myself entirely in agreement with Sir John Cockcroft about the seriousness of the crash-hazard problem in aviation, and I wonder why the U.S. is spending so much effort on this application. Dr. Dunworth briefly but effectively debunks the optimistic idea that it will be possible to reclaim large areas of the world's deserts by means of nuclear power.

A number of articles dealt with problems of instrumentation, control, and health risks. There is also a brief description of the development plans for nuclear energy in France.

There are two accounts of the uses of radioisotopes. In one of these, Dr. R. Roberts describes possible uses of fission products in sterilisation, insect control, and for inducing chemical reactions. But he gives a warning against over-optimism in the case of bulk treatment of chemical materials, showing that only where the radiation causes a chain reaction is the cost likely to be acceptable. This article is suggestive of many possibilities which will have to be explored.

Finally, there is a short article in which Professor Frisch accepts the case for the "three-decker" mechanism (fission-fusion-fission) of the H-bomb, and a brief review of the achievements of modern nuclear physics by Prof. Pryce.

These notes, stressing chiefly the points which happen to have struck one reader, may not adequately cover the whole supplement, but I have no hesitation in recommending a thorough reading of the contents, with one exception: The Glossary of Terms contains several crude and elementary mistakes, the definitions being in some cases completely wrong.

H. W. B. SKINNER

Proceedings of the Second International Congress on High-Speed Photography and Cinematography

Edited by P. Naslin and J. Vivie (*Paris, Dunod, 1956, XXVIII+455 pp., £6.*)

High-speed photography and cinematography are precision research techniques which have been applied in nearly all branches of the experimental sciences, from the movement of living cells to the explosion of hydrogen bombs. They are by no means new techniques, and it was Mach in 1880 who first used electric sparks to illuminate and photograph ballistic events; Marey, only ten years later, published his first high-speed cinematograph records of the flight of birds. Perhaps the year 1904 should also be mentioned, the year when L. Bull combined spark illumination and cinematography and solved the problem of insect flight mechanism.

Fifty years later, in 1954, the second international congress on high-speed photography and cinematography took place in Paris, with Bull as chairman of the organising committee. The first international congress was held in Washington in 1952, and the third will be opened in London during September 1956 and is sponsored by DSIR. This official Government recognition is alone sufficient proof of the importance of the subject; one glance at the proceedings of the second congress amply demonstrates the reason for this distinction.

The proceedings are divided into fourteen parts, dealing with flash lamps and flash cameras, radiography, high-speed shutters, mechanical-optical cameras, image-dissecting cameras, sensitive films, illumination, diverse applications, ballistics, shock stress and rupture phenomena, schlieren and interferometry, biology and medicine, metallurgical and mechanical engineering applications, and finally atomisation phenomena. Befitting to the international character of the congress, the proceedings are in French, German, and English, each paper being printed in the language in which it was delivered, but prefaced by a very full summary in all three languages. All captions to photographs are also in three languages. Regrettably, but perhaps not surprisingly, a small number of typographical errors could be noticed in English and German.

A total of sixty-eight papers have found their way into the proceedings by such distinguished scientists as M. LaPorte, W. D. Chesterman, A. Karolus, E. W. Walker, R. Thun, J. S. Courtney-Pratt, J. H. Waddell, M. Sultanoff, H. Schardin, R. Piédelièvre, and P. Devaux. Their ingenious techniques of high-speed photography and cinematography, together with the numerous applications described, present to the reader an up-to-date and exhaustive review of the subject. It would be invidious in this brief note to single out one specific research technique or its application; suffice it to state that apart from one general review and a few brief summaries, all contributions are of the highest standard and deal with the most recent practices.

The editor-in-chief, Ingénieur Militaire Principal Naslin, is to be highly congratulated on the excellent presentation of the proceedings. Lavishly illustrated with extracts from high-speed films, with photographs, charts, tables, and diagrams, spaciously laid out and beautifully bound, the proceedings are a pleasure to behold. Most outstanding are the colour photographs of aluminium welding processes reproduced from 16 mm. high-speed films. This volume will find its rightful place wherever in the world high-speed photography and cinematography are practised, in the university, in industry, and in government laboratories. It will act as an inspiration to the worker in the field, and as a stimulus to those who have not yet brought these powerful research techniques to bear on their own researches.

A. R. MICHAELIS

Roman Roads in Britain: I

By Ivan D. Margary (*London, Phoenix House, 1955, 256 pp., 16 plates, 11 Maps, 42s.*)

Mr. Margary's flair for tracing the courses of Roman roads, which found expression in 1948 in his *Roman Ways in the Weald*, is now resulting in a fine work in two quarto volumes on the

Roman roads of Britain, of which the first volume, now issued, covers those south and east of the Bristol Channel and the Fosse Way. The introductory chapter consists of a masterly account of the characteristics and structure of Roman roads, and the methods used in tracing them. Among the latter may be noted probing study of Anglo-Saxon Land Charters and other documentary sources, and air-photography. The study of air-photographs has resulted in the discovery of hitherto unsuspected Roman roads (e.g. that between Chichester and Milland, perhaps continuing to Silchester, p. 71), and has assisted in determining the precise course of parts of others (e.g. that between Badbury Rings and Donhead St. Mary, p. 98). Mr. Margary has been careful to follow up air-photographic and other clues in the field. A notable feature of the text is the author's ingenious though simple system of numbering the roads.

Of the sixteen plates, eight are air-photographs (seven by Dr. St. Joseph and one by the late G. W. G. Allen) of the highest quality, which provide a finer view of these roads than the Romans themselves ever had.

The only criticism which the present reviewer desires to offer is in regard to the Index, and it is hoped that this may be covered by the inclusion of a subject index to both volumes at the end of Volume II, as befits a book that will be a standard work for many years. Of some 750 references in the index to Volume I, well over 700 are of place-names only. Important matters such as posting stations, wells, pigs of lead, Roman barrows, Roman milestones, are omitted from this index.

L. V. GOLDSELL

The Observer's Book of Mosses and Liverworts

By Arthur L. Jewell (*London, Frederick Warne, 1955, 128 pp., 64 plates by E. C. Mansell, 32 of them in colour, 5s.*)

This new addition to a well-known series of pocket natural history books fills a long-felt gap in the amateur naturalist's library. The mosses and liverworts are two of the most neglected groups in our flora, and this is perhaps partly because of the almost complete absence of simple books about them.

A brief introduction gives a useful account of the biology, of the two groups, and is followed by detailed descriptions of 116 species. The plates, half of them in colour, are simple and straightforward; it was a good idea to number the detailed drawings all on the same plan, so that a simple key covers all of them. At the end are short sections on the uses of mosses (their collection and cultivation), and a guide which will be useful to the naturalist in his search for the various species. A good point is the inclusion of index and bibliography, a somewhat unusual feature for so small a volume.

With the modern ecological approach to natural history, mosses, among the first living things to colonise many sites, should attract increasing attention, and this book will provide an excellent beginners' guide to their identification.

P. B. C.

Plants and Animals of the Sea-Shore

By W. J. Prud'homme van Reine. Translated from the Dutch and adapted for the coasts of Britain in collaboration with Mona C. Harrison. Illustrated by L. P. Pouderoyen and Jos Ruting (*London, John Murray, 1956, 138 pp., 8s. 6d.*)

There are many good books for the amateur naturalist on the life of the sea-shore. Nevertheless this "handy guide", as it is described in the sub-title, can supplement more detailed works and is compact enough to carry about. More than 450 species of plants and animals are included. Each is entered under its main class by common name, and is described by three to eight lines of text to help in identification. The illustrations are very fine and give an excellent impression of three dimensions. Five of the plates are in colour. Each main class is introduced by one or two pages of text. An index lists both common and scientific names. A short list of books for further reading is appended, and also a glossary of terms. The book is intended to assist in identification of plants and creatures which have already been found, and makes no attempt to lead the collector to localities where particular types may be sought. The descriptions are brief to the point of inadequacy, so that it is unlikely that by using this aid alone specimens lacking some obvious specific characteristic could be identified. Definitions in the glossary are mostly too brief to be helpful and could lead to misunderstanding. Nevertheless, if more is not expected of this introductory manual than it sets out to achieve, the purchaser will not be disappointed with his bargain. A better book could hardly be chosen to start a youngster off on finding interest in the life around our shores. Paper and printing are both excellent.

W. ASHWORTH

Brief Notes

Publication of the *Proceedings of the World Symposium on Applied Solar Energy* is announced from 204 Heard Building, Phoenix, Arizona, at a price of $5.00 post paid. The proceedings deal with solar water heaters, solar collector design, solar energy conversion, and algal culture studies.

The *Scientific Film Review* for April 1956 contains notes on industrial film making, on the use and abuse of film and medical illustration, and on physics and underwater research. It is available from 164 Shaftesbury Avenue, London, W.C.2, price 3*s.* 6*d.*

A summary of French scientific activity may be obtained from Gauthier-Villars, 55 Quai des Grands-Augustins, Paris, 6. An illustrated brochure, "Charbonnages de France: Resultats et Perspectives, 1954, 1955", is available from the French Embassy, London.

The April 1956 issue of the *Comptes Rendus de Recherches*, published by the Institute for the Encouragement of Scientific Research in Industry and Agriculture, 53 Rue de la Concorde, Brussels, is devoted to research on buckling of steel stanchions under oblique loading.

In July 1955 *Italian Affairs* published a fully documented list of the aims, functions, and range of the institutes and study centres dependent on the Italian National Research Council. The present issue is completing the survey with a list of the institutes, laboratories, and experimental stations dependent on government organisations. Fifty institutes are listed which have been set up by Italian industrial groups and companies to study new manufacturing processes, examine raw materials, and carry out experiments, so that Italian industries may compete on equal terms with their foreign counterparts.

The December 1955 issue of the "World Catalogue of Genetic Stocks of Wheat", published by the Food and Agricultural Organisation of the United Nations, includes contributions from Belgium, Egypt, India, South Africa, and the U.S.A.

A symposium on "Marine and Freshwater Plankton in the Indo-Pacific Ocean" was held in Bangkok in January 1954 and has recently been made available from the South-East Asia Science Co-operation Office, Djl. Diponegoro 76, Kjakarta, Indonesia, at a price of 5*s.*

"Physical Aspects of Absorptiometric Analysis" is the title of Special Report No. 55 of the Iron and Steel Institute, 4 Grosvenor Gardens, London, S.W.1.

Forestry workers will be interested in Bulletin No. 36 of Forest Products Research, on "Mernati, Seraya, and Allied Timbers" (H.M.S.O., price 2*s.* 6*d.*), and also in the 35th Annual Report (1954–5) of the Imperial Forestry Institute, the Holywell Press, Oxford.

The National Physical Laboratory publishes "Standard Capacitors and their Accuracy in Practice". Its purpose being to draw attention to factors which affect the performance of capacitors because of their construction and method of use (H.M.S.O., price 1*s.* 4½*d.* post free).

"Copper Wire Tables", 4th Edition, National Bureau of Standards Circular 31, may be ordered from the U.S. Government Printing Office, Washington 25, D.C. These tables are of importance to workers in the copper industry, electrical engineering, and related fields. All data in "Copper Wire Tables" is expressed in both English and metric units. In this edition the tables have been extended to 50 gauge and up to 200°C.

NEW SCIENTIFIC INSTRUMENTS

This feature is designed to provide information about new scientific instruments which have come on the market. The detailed facts in it are the responsibility of the manufacturers, being taken from literature supplied by the makers. The editor will welcome information from manufacturers about new scientific instruments they are putting on the market. As these notes are intended for the large section of our readership composed of professional scientists, etc., we depart from our customary practice and use symbols and abbreviations to the full in order to be able to convey the maximum amount of detailed information.

Transfer Function Analyser

This equipment will indicate to a first order the resolved components of a test signal at the output of a servo-amplifier or similar device. By employing the wattmeter principle for phase resolution the display is unaffected by harmonic distortion even though this may be comparable in amplitude to that of the fundamental test frequency. The equipment comprises an l.f. decade oscillator (type OS 103) which provides a sinusoidal disturbance of known voltage and frequency to the system under test, and a l.f. phase sensitive voltmeter (type VP.253) which directly indicates the resulting signal at the desired point of measurement. This instrument displays the measured signal in the form of two resolved voltage components utilising the oscillator output voltage as phase reference.

The transfer function analyser may be used for many investigations where it is desirable to present information in the form of a Nyquist diagram disregarding harmonic distortion, and is particularly suitable for investigation of the behaviour of large structures such as air frames under forced vibrations.

The Solartron Electronic Group Ltd., Thames Ditton, Surrey.

Loudspeaking Telephone System

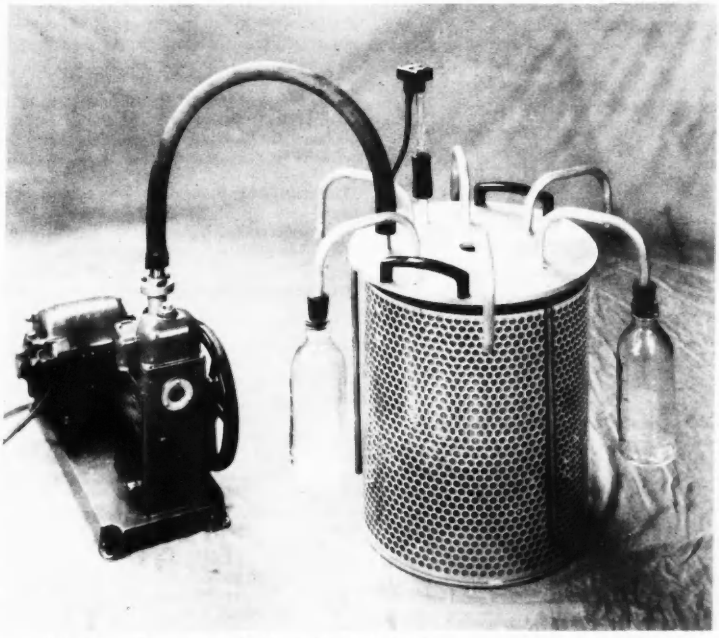
In telephonic communication it is sometimes convenient for the sender not to have to speak directly into a microphone and for the receiver of the message to use a loudspeaker. Either or both of these arrangements for two or more people is provided by the Winston Electronics system of "no hands" loud-to-loud telephonic communication which will enable conferences to take place between people at a distance. It can be supplied as a complete system on its own, as component parts to be fitted by intercommunication telephone manufacturers into their own cabinets, or as the "Adaptaplinth", for attaching to existing hand-sets which will convert these into loudspeaking telephones with ample loudspeaker volume. When a call is received in the "Adaptaplinth" system, the bell of the hand-set rings and the person answering either lifts the hand-set for secrecy or depresses the key for "Tellaloud" conversation. When the user makes a call he first depresses the line key which loops the line and causes the dialling tone to be heard in the loudspeaker, then dials in the usual way.

The system is suitable for internal, external local, and long-distance calls (it has recently been subjected to a series of eighteen trans-continental tests between Rome–Madrid, and Paris–London, etc.). It can be used with private automatic, automatic branch, magneto, or branch exchanges and with 1-, 2-, 3-, or 4-wire systems. It is easily installed and operates successfully loud-to-loud or loud-to-soft in locations having an ambient noise level of 75 phons of "white" noise. The time constant of the switching gear is less than 3 ms.; the performance is independent of varying mains supply, and it will not "sing". If a user wishes to break into a loud-to-loud conversation he just raises his voice as in ordinary conversation, and there is a volume control on the loudspeaker. The manufacturers state that maintenance is trouble-free as all components are underrun and the equipments are soak-tested and aged for 200 hours before leaving the factory. Selenium metal rectifiers are used, and heavy negative feed-back at each amplifying stage ensures automatic compensation as the valves age. The valves are easily obtainable types for replacement, the amplifier components accessible, and the mains transformer electrostatically screened and earthed.

Winston Electronics Ltd., Shepperton, Middlesex.

Simple Freeze-drying Unit

The 10P unit is intended to provide an inexpensive source of freeze-drying for small-scale production quantities and research work handling either bottle or ampoule-contained material; it has been designed for use with existing vacuum pumps and consists essentially of a 12 in. diameter inverted metallised bell-jar covered with a removable metal cover plate. This is provided with ports for attaching bottles or a small ampoule header in addition to the central hole for the 5-litre refrigerant flask. Drying is carried



10P Freeze Dryer assembled and fitted with a Pirani gauge head and with MRC bottles mounted on the drying spouts. A "Speedivac" 1SC50 Rotary Pump is shown mounted externally.

out in two stages. The bulk of the moisture is first removed by evaporation under low pressure and frozen in the refrigerant cooled condenser. The remaining moisture down to a fraction of 1% is absorbed by a tray of phosphorus pentoxide inserted in place of the flask. The figure shows the freeze drier apart from the bell jar with the refrigerant flask and an ampoule header in position. The capacity of the unit is up to 2·4 litres of ice.

Edwards High Vacuum Ltd., Manor Royal, Crawley, Sussex.

Pocket Radiation Monitor

The battery radiation monitor (type 4010) of dimensions 168×43×105 mm. and weight only 730 g. is designed for general survey and location of radioactivity, and is tropicalised and waterproofed (see Fig.). It is sensitive to γ-radiation high energy β-radiation and x-rays. The impulses from the Geiger tube (high sensitivity, low voltage, halogen-filled, self-quenching, type 18512) produce bursts of oscillations in a valve circuit which are indicated by a micro-ammeter calibrated in counts/sec. The oscillating anode current of the valve is passed through the primary winding of a transformer. The high voltage produced in the secondary winding is rectified and charges a capacitor which provides the voltage source for the Geiger tube. The anode batteries are long lasting since they supply current only when the tube registers counts. Light-weight earphones can be provided to detect very low intensities. There are two ranges 0–40 counts/sec and 0–800 counts/sec corresponding to about 0–1·25 and 0–25 mr/h. No separate probe is necessary as the instrument itself is used for this purpose.

Pocket Radiation Monitor.

Philips Electrical Ltd., Century House, Shaftesbury Avenue, London, W.C.2.

Protective Screen for Laboratory Use

A protective screen of transparent plastic to Royal Aircraft Establishment specification, mounted in an aluminium alloy angle and sheet steel framework at 8° from the vertical, is being marketed to reduce the danger of personal injury from accidental explosions in school and other laboratories. It has withstood on test the explosion of a 2·5 : 1 mixture of acetylene and oxygen in a 100 c.c. flask 8 in. away from the screen.

Baird and Tatlock (London) Ltd., Freshwater Road, Chadwell Heath, Essex.

FAR AND NEAR

The Royal Society

The following scientists have been elected Foreign Members of the Royal Society:

KAI ULRIK LINDERSTRØM-LANG, Copenhagen. For his contribution to protein chemistry and for his pioneer development of ultra micro-techniques for the biochemical study of the localisation of enzymes in tissue cells.

HANS PETTERSON, Göteborg. For his researches in oceanography.

ROBERT BURNS WOODWARD, Cambridge, U.S.A. For his investigations in organic chemistry especially on the synthesis of important natural products such as quinine, cortisone, and antibiotics.

FRITZ ZERNIKE, Groningen. For his researches in phase-contrast microscopy.

At the invitation of the Academy of Sciences of the U.S.S.R. the Royal Society is sending a delegation to Moscow under the auspices of the Soviet Relations Committee of the British Council. The delegation will leave on May 18, 1956, and will spend a fortnight in the U.S.S.R. visiting scientific institutions. Lord Adrian, O.M., will lead the delegation, and other members are: Lady Adrian; Dr. H. G. Thornton, Foreign Secretary of the Royal Society and Head of the Department of Soil Microbiology at Rothamsted Experimental Station; Miss M. L. Cartwright, F.R.S., Mistress of Girton College, Cambridge; Prof. J. H. Gaddum, F.R.S., Professor of Pharmacology in the University of Edinburgh; Prof. J. M. Robertson, F.R.S., Professor of Chemistry and Head of the Chemical Laboratories of the University of Glasgow; Prof. M. Stacey, F.R.S., Professor of Chemistry in the University of Birmingham; Dr. D. C. Martin, Assistant Secretary of the Royal Society.

The Night Sky in June

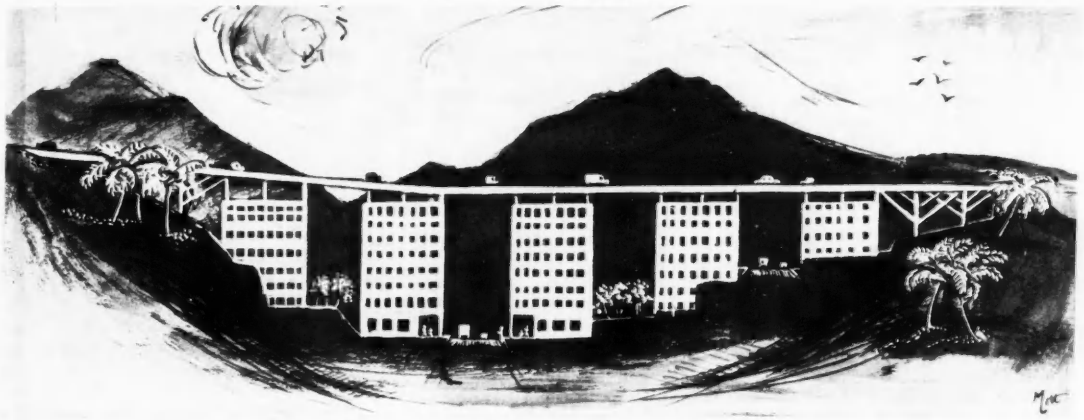
The Moon.—New moon occurs on June 8d 21h 29m, U.T., and full moon on June 23d 06h 13m. The following conjunctions with the moon take place:

June

1d. 00h	Mars in conjunction with the moon	Mars	8°S.
7d 18h	Mercury	Mercury	5°S.
10d 05h	Venus	Venus	3°N.
13d 15h	Jupiter	Jupiter	7°N.
20d 11h	Saturn	Saturn	3°N.
29d 14h	Mars	Mars	10°S.

In addition to these conjunctions with the moon, Mercury is in conjunction with Aldebaran on June 23d 08h, Mercury being 2°.5N.

The Planets.—*Mercury* is too close to the sun during the greater part of the month for observation; at the end of the month it rises at 2h 45m, which is an hour before sunrise, and may be seen for a short period before sunrise as it shines with a brightness greater than that of a first-magnitude star. *Venus* sets at 22h 30m on June 1, but after this it gradually sets closer to the time of sunset and at the middle of the month sets only half an hour after sunset; during the remainder of June it cannot be favourably observed. *Mars* rises at 0h 45m, 0h 10m, and 23h 25m on June 1, 15, and 31 respectively. Its stellar magnitude varies from −0°.3 to −0°.9 during the month, which implies that it becomes brighter. This is due to the fact that the visible portion of its illuminated disk increases from 0·859 to 0·875, and also its distance from the earth decreases from 76 to 58 million miles. It has an eastward movement in the constellation Aquarius, and at the end of the month is close to a group of rather faint stars in this constellation. *Jupiter* is visible soon after sunset and sets at 0h 25m, 23h 30m, and 22h 40m on June 1, 15, and 20 respectively. Its stellar magnitude varies between −1·5 and −1·4; the decrease in brightness is due to its distance from the earth increasing from 520 to 557 million miles during June. It moves closer to Regulus—the brightest star in the constellation Leo—during the month. *Saturn* can be seen after sunset in the constellation Libra and sets in the early morning



An artist's impression of the proposed rooftop road for Amman.

hours at 3h 30m, 2h 35m, and 1h 30m on June 1, 5, and 30 respectively. It is a little brighter than a first-magnitude star, but decreases slightly in brightness owing to its distance from the sun increasing from 835 to 855 million miles during the month. The sun attains its greatest declination north on June 21, and the days are then longest in the northern hemisphere. In the latitude of Greenwich the sun rises at 3h 42m and sets at 20h, i.e. at 8 p.m. on that day. No notice is taken of summer time in any of the above data, and readers must make the necessary corrections for this.

Rooftop Roads Planned for Amman

A British firm of planning consultants has produced a remarkable new plan for the Jordan capital, Amman, and this has now received the approval of King Hussein. Max Lock and Partners, the post-war surveyors of Middlesbrough, were commissioned by the United Nations as part of its programme of technical aid to Jordan to advise the government on all aspects of planning.

Two main problems faced the planners. Amman, with 40,000 inhabitants in 1946, now has a population five times that number and is still expanding. The city's configuration is awkward, too. The only roads are those that radiate from the centre where the original settlement was built at the confluence of seven "wadis" cutting deeply into the desert plateau. Building has spread up the inner sides and flat tops of the intervening "jebels" or plateaux. To get from one district to another one must either walk down one steep stairway and up another or drive into the congested city centre and out again. A traffic census conducted by the planners in conjunction with the Arab Legion has shown that city traffic is largely made up of internal "circulation" of this sort.

An inner ring-road linking the mountain tops is proposed, to relieve the jam in the centre. In several places this involves extensive bridgework. The planners intend to carry the bridges on the roofs of blocks of flats (with four flats to each floor) up to eight storeys high. The short distance between blocks allows the roadway to be of light construction. The specially designed supports should absorb enough traffic vibration to prevent this being troublesome to the people living in the flats. (See Fig.)

The Amman plan is the result of twelve months' work. It is only one of several Jordan cities for which the British consultants are making proposals.

Looking for Astrolabes

The first astrolabe was produced in the year A.D. 950 by Ahmad Bin Khalaf, and the last in the 19th century. Between these two dates more than a thousand instruments of this kind were lovingly constructed both in Western Europe and the Middle East, and it will prove a great help to museum authorities and collectors of scientific instruments that Dr. D. J. Price of Christ's College, Cambridge, has compiled a nearly complete list of all these instrumets, called "An International Checklist of Astrolabes" and published recently by the *Archives Internationales d'Histoire des Sciences*.

The checklist is divided into a number of indices giving Western astrolabes in chronological order, Western astrolabes by museums and collections, Eastern astrolabes in chronological order, and Eastern astrolabes by museums and collections. It is interesting to note from a statistical analysis that the largest collection, a total of 84 astrolabes, is held by the Oxford Museum of the History of Science, and that a close second is the National Maritime Museum, Greenwich, with a total of 50 astrolabes. England therefore has by far the largest number of these interesting instruments, which were described and illustrated by Dr. Price in the April issue of DISCOVERY, p. 153. What is noteworthy also is the fact that fake reproductions of these instruments have now appeared. Dr. Price appeals to all museums and private collectors to keep him informed of astrolabes not mentioned in the check list and to correct any possible errors.

Popular Ornithologist Honoured

Peter Scott, the painter and bird-watcher, has been awarded the Television Society's Silver Medal for 1956, for "outstanding artistic achievement in television".

It's Hotter than the Sun at Everett

The Avco Research Laboratory, Everett, Massachusetts, has developed a 100-foot tube which fires shock-waves hotter than the surface temperature of the sun. The waves travel twenty-five times faster than sound. The device, described as "a distant relative of the wind-tunnel", will provide scientists with data of use in the design of long-range missiles and earth satellites. The shock-waves create for a fraction of a second conditions comparable with those to be met by earth-satellites and inter-continental missiles.

The tube is powered by gas under very high pressure. Electronic instruments and cameras measure the speed of waves along the length of the tube.

Two-year Drive Against T.B. in Scotland

Scottish health authorities are worried at the large number of tuberculosis cases being reported. To attack the "reservoir of infection" they are therefore planning a national case-finding drive against the pulmonary form of the disease. It promises to be more ambitious than anything of the sort previously attempted in Great Britain. The Ministry of Health and the RAF are lending diagnostic units for the two-year campaign.

Industry Sponsors Art

Messrs. Richard Thomas and Baldwins Limited, a leading steel manufacturing company, offered prizes for paintings on the theme "Industrial Britain". A selection of the 1200 entries have recently been on view at the Chenil Gallery, London, and will be touring the provinces.

Although the themes were interiors of factories, or streets and landscapes with the traces of industry upon them, the treatment often suggested a nostalgia for days when such things did not exist. The people in these paintings looked lost and forlorn, even when the artist intended quite the opposite, as they stood against backgrounds of blast furnaces and grimy warehouses. The reason for this apparent desire to put the clock back may lie in the conservatism of our vision. Our eyes see differently in different ages, and it is only the great innovators who leap ahead of fashion. The Egyptians probably did in fact *see* people simultaneously full face and in profile. Europeans before Giotto did not *see* in three-dimensional perspective, and we do not know how long it was before the man in the street adjusted himself to the "new look". Picasso actually *saw* landscapes as if from an aeroplane before he had ever flown; yet most of us who have done so are still earth-bound in our vision.

Changes in the fashion of seeing come about through many complicated factors. In an exhibition of works by young artists and students we cannot expect innovations. Nevertheless it is surprising that most of the artists in this exhibition have been content to see as Cezanne and Manet taught them, and not as our new age *looks*. One of the most "modern" paintings in this sense is of a windmill which, although it is remote from the camera age, is seen from an angle to which the camera has accustomed us—and this not arbitrarily but with an eye to the design.

The sponsors of the competition are to be congratulated on an excellent idea. The artists have achieved a high standard of skill and very often of composition. But they might learn a little from a closer study of industrial design; gas-turbine coaches, jet planes, and many new scientific instruments have their own beauty, determined by necessity.

Instructional Film Research Programme

In 1947 the American Navy initiated an instructional film research programme and gave a special contract for research on the efficacy of visual teaching methods to the Pennsylvania State University. This programme has proved very successful under the directorship of Dr. C. R. Carpenter, and many reports have been issued by the American Navy on the results achieved. Experimental studies with, and on, films were devoted to the teaching of performance skills, the teaching of facts and principles, the investigation of methods for utilising instructional films, and the "restructuring" of attitudes. The research contract with the Navy came to an end in August 1955, but the University of Pennsylvania has now taken over the whole programme and it is being continued.

Promoting Science Among the Young

To help teachers get their pupils to take a greater interest in science, New York University is holding a "Science Teachers' Workshop" during July. The faculty will be drawn from three of its departments. The programme will include lectures by visiting scientists as well as by the University's own men, visits to local laboratories, demonstrations and experiments, specialist discussion groups, and tutorials on effective science teaching. Specific study will be given to microwaves, histophysiological changes, endocrine-physiology, radio biology, biophysics, cytochemistry, nuclear fission and fusion.

It appears that the United States are running short of scientists too. "Each year fewer young people are selecting scientific courses of study," said Ralph E. Pickett, associate Dean of the University, when he announced the "Workshop" which he will supervise. The "heavy burden" of matching the supply of professional scientists to the demand falls on the elementary and high-school teachers, added Dean Pickett.

Kenya's Royal Technical College

The first students began work at the Royal Technical College, Nairobi, last month. This was the culmination of nine years of planning and building. The college offers courses in engineering, commerce, architecture, and art, in science and in arts. The first year's 200 students will study all but the last two subjects. The examinations of British professional bodies (such as the Town Planning Institute or the Institution of Electrical Engineers) will be taken.

The college has been granted £866,500 for capital works by Great Britain and the three East African governments. The Gandhi Academic Memorial Society and Shell and BP companies have also contributed. The college is intended ultimately to hold 1500 full-time and 1000 part-time students. This year there were twice as many applications as there were places.

Saving Water in Australia

Evaporation losses up to 8 feet a year occur in many of Australia's arid regions. A saving of 45% of normal evaporation means saving 1 million gallons per acre of reservoir surface. Recent large-scale field trials by the Commonwealth Scientific and Industrial Research Organisation in the use of cetyl-alcohol to reduce water evaporation, has confirmed earlier tests. Evaporation has been cut from between 20% and 70% by spreading an invisible film of cetyl-alcohol on the surface of lakes and reservoirs. This restricts the transfer of water to the air but does not hinder the solution in the water of oxygen from the air. This keeps the supply fresh. The cost of treatment, judging by the recent tests, is about 2½*d.* per 1000 gallons saved. The financial gain to graziers and water boards per annum will be hundreds of thousands of pounds.

A snag developed recently. Local Temperance Leagues objected to "that demon alcohol polluting" the water supplies. When the substance is called *hexadecanol*, however, no one is offended.

Considerable interest has been shown outside Australia in the new technique. Supplementary tests have been carried out in India and Kenya, and Mr. W. W. Mansfield, responsible for the Australian research, has just returned from advising Texans on the process.

Hungarian Transplants Human Teeth

An Hungarian dentist claims to have successfully transplanted human teeth. This follows experiments with animals. The transplant is the "embryo" tooth; he gets these when the extracting of a child's bad tooth bring an embryo with it—as sometimes happens—or from accident cases. Dr. Miklos Cserepfalvi has transplanted sixteen human teeth so far. If the new tooth "takes", it grows in two weeks. More research proceeds on this work.

Belgians Break their Record—Blame Us

A British automatic signalling system installed on Belgian railways in 1950 is blamed for two serious and several minor rail accidents, in a recent report published in Brussels. Until 1951 Belgian State Railways held the world record for safety. Last year nineteen German football fans were killed in a crash during poor weather. R/T communications are recommended in place of the automatic method.

Canadian Scholarships for 1956–7

The National Research Council of Canada has granted 269 scholarships for 1956–7, with a total value of $345,500, all to be held in Canada.

Special scholarships for study abroad include twenty-seven worth $2000 each, to be held in the following countries: nine in the U.S.A., fifteen in the United Kingdom, one in France, and two in Sweden.

Twenty-two postdoctorate overseas fellowships at $2500 each have been granted for work in the following countries: fourteen in the United Kingdom, one in Germany, three in France, one in the Netherlands, and three in Switzerland.

Caribous Dwindling

The caribou population of North Canada has shrunk to 300,000 from

many millions in the last few years according to the recent report published by the Canadian Wildlife Service. Lately trappers reported that some of the long sandy ridges round the shores of Athabaska and Great Slave Lake were "white with caribou bones". This may be due to starvation, wolves, or an attack of the widespread caribou disease, hydatid cyst (a worm infection of lungs and liver).

The destruction of the caribou means that more tribes of Indians and Eskimos will perish. The bands of Chipewyans, Dogribs, Hares, Slavvies, and Tanaki in this area are trappers who depend on caribou for food and other needs. Once these Indians drift to the new townships they lose their tribal identity and become, in effect, displaced persons.

Synthetic Rubber to Save Dollars

The first large-scale synthetic rubber installation in Britain is soon to be erected at Fawley, Hampshire. Two plants are envisaged in the scheme. At the Fawley Esso Refinery a new factory for the production of *butadiene* (a petroleum gas) will supply a £5-million-synthetic-rubber-production plant of the International Synthetic Rubber Company (a subsidiary of Dunlop). When this twin project comes into production about 1958 the output of GR-S rubber should be 50,000 tons: equivalent to Britain's present imports of American rubber. This will save about $30 million a year.

Robots Not Robbers in the Bank

The First National City Bank of New York claims to be the first bank on earth to have an "electronic brain" to do about 85% of its accounting. The machine is a Burroughs E-101 with a 100-cell memory capacity. A 220-cell machine is ordered.

Isotopes to Move Down the Road?

The United Kingdom Atomic Energy Authority is probably taking over the RAF station and airfield near Wantage, Berkshire, for the "technological irradiation group" under Dr. H. Seligman, which is expanding. Work on isotopes has become one of the main concerns at Harwell. The large hangars at the RAF site are readily adapted for research purposes.

"Window of the Heavens"

Harvard University have recently dedicated a new "window of the heavens", a radio telescope which is expected to reveal details of the great spirals of the Milky Way and of the lightless clouds of hydrogen said to contain 50 to 100 times as much material as the sun. The antenna of the telescope has a diameter of 60 ft., and is mounted on a 50-ft. tower. Although the biggest instrument in the U.S.A., there is a bigger one in Holland, and the 250-ft. high instrument now being constructed at Jodrell Bank will be larger than either. CSIRO in Australia are also building a 200-ft. telescope.

Ohio State University has begun the construction of a still larger radio telescope. Its antenna will be a fixed parabolic metal screen 700 feet long and 75 feet high, facing a flat but movable screen of about the same size. The radio waves, after reflection, will be fed into a sensitive receiver. The screen is being designed by J. D. Kraus, and part of the money for it is being made available by the National Science Foundation of the U.S.A.

British Chemical Engineering

A new journal under the above title made its appearance in May. Its Editor is Mr. W. E. Dick, previously Editor of DISCOVERY. Among the interesting articles in this journal is one on Britain's first synthetic rubber plant, and another on chemical engineering achievements at Windscale, the Cumberland Plant of the United Kingdom Atomic Energy Authority. It is hoped to publish a full review of this journal in due course.

Continued on p. 262

Classified Advertisements

OFFICIAL APPOINTMENTS

ASSISTANTS (SCIENTIFIC): The Civil Service Commissioners invite applications for pensionable posts.

Age at least 17½ and under 26 years of age on January 1, 1956, with extension for regular service in H.M. Forces, but candidates over 26 with specialised experience may be admitted.

Candidates must produce evidence of having reached a prescribed standard of education, particularly in a science or mathematical subject. At least two years' experience in the duties of the class gained by service in a Government Department or other civilian scientific establishment or in technical branches of the Forces essential in one of the following groups of scientific subjects:

(i) Engineering and physical sciences.
(ii) Chemistry, bio-chemistry and metallurgy.
(iii) Biological sciences.
(iv) General (including geology, meteorology, general work ranging over two or more groups (i) to (iii) and highly skilled work in laboratory crafts such as glass-blowing).

Inclusive salary scale £302 (at 18) to £611 (men) or £528 (women). Starting pay up to £449 (men) or £407 (women) at 25. Women's pay subject to improvement under equal pay scheme. Somewhat less in provinces. Opportunities for promotion.

Further particulars, for which you are advised to make early application, from Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting No. S.59/56.

EXPERIMENTAL OFFICERS AND ASSISTANT EXPERIMENTAL OFFICERS in various Government Departments. The Civil Service Commissioners invite applications for pensionable posts.

The posts are divided between following main groups and subjects (*a*) Mathematical and Physical Sciences, (*b*) Chemistry and Metallurgy, (*c*) Biological Sciences, (*d*) Engineering subjects and (*e*) Miscellaneous (including, e.g. Geology, Library and Technical Information Services).

Age limits: For Experimental Officers, at least 26 and under 31 on December 31, 1956; for Assistant Experimental Officers at least 18 and under 28 on December 31, 1956. Extension for regular service in H.M. Forces. Candidates aged 31 or over with specialised experience for Experimental Officer posts may be admitted.

Candidates must have at least one of a number of specified qualifications. Examples are Higher School Certificate, General Certificate of Education, Scottish Leaving Certificate, Scottish Universities Preliminary Examination, Northern Ireland Senior Certificate (all in appropriate subjects and at appropriate levels), Higher National Certificate, University degree. Candidates taking their examinations in 1956 may be admitted. Candidates without such qualifications may be admitted exceptionally on evidence of suitable experience. In general a higher standard of qualification will be looked for in the older candidates than in the younger ones.

Salary (London):

Experimental Officer £838–£1008 (men); £742–£914 (women).

Assistant Experimental Officer £342 (at age 18) to £736 (men), £664 (women). Starting pay up to £611 (men) or £567 (women) at 26 or over. Somewhat lower outside London. Promotion prospects. Women's scales being improved under equal pay scheme.

Further particulars, for which you are advised to make early application, from Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting No. S94-95/56.

SPECIALIST ASSISTANT required by GOVERNMENT OF NORTHERN REGION NIGERIA Agricultural Department for one tour of 12–24 months in first instance either (*a*) with prospect of pensionable employment—salary scale (including inducement addition) £750 rising to £1554 a year—or (*b*) on temporary terms—salary scale (including inducement addition) £810 rising to £1716 a year plus gratuity at rate of £100–£150 a year. Commencing salary according to experience. Outfit allowance £60. Free passages for officer and wife. Assistance towards children's passages and grant up to £288 annually. Liberal leave on full salary. Candidates, preferably under 35, must be highly trained in Laboratory techniques of either Plant Pathology or Entomology, and should possess Diploma of INSTITUTE OF SCIENCE TECHNOLOGY or similar qualification or experience. Write to the Crown Agents, 4 Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience and quote M3A/35303/DI.

FIELD OFFICER required by KENYA Government Tsetse Survey and Control on contract for one tour of 36–45 months in first instance with gratuity 13½% total salary drawn. Salary scale (including inducement pay and present temporary allowance of 10%) £772 rising to £1280 a year. Commencing salary according to experience. Outfit allowance £40. Separation allowance payable. Free passages. Liberal leave on full salary. Candidates, under 36, should preferably have experience of East African conditions including supervision of labour in the field and technical knowledge of practical tsetse problems. Consideration will be given to applicants, with degrees, not having the above experience. Write to the Crown Agents, 4 Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience and quote M3A/43246/DI.

AIR MINISTRY: SENIOR SCIENTIFIC OFFICER. The Civil Service Commissioners invite applications from men for a pensionable post in the Meteorological Office, Harrow. Age at least 32* on December 31, 1956. Candidates must have a University degree with first or second class honours in Physics, or, produce other evidence of outstanding suitability. They must have had at least 3 years' post-graduate or other appropriate experience. Extensive knowledge of climatological problems and of punch card procedure, and considerable experience of synoptic and marine meteorology essential.

Inclusive salary (for 45¼-hour week) £1225 to £1415. Exceptionally, starting salary above minimum.

Particulars and application forms from Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting No. S4591/56/8. Application forms to be returned by June 7, 1956.

* Candidates under age 32 on December 31, 1956, may be considered, but must apply by June 7, 1956, through the normal open competition, quoting No. S4591/53/56/8.

APPOINTMENTS VACANT

EDWARDS HIGH VACUUM LIMITED, MANOR ROYAL, CRAWLEY, SUSSEX, for their research and development expansion invite applications from suitably qualified staff for the following posts.

(1) *Physicists*. (Graduate or equivalent) preferably with High Vacuum experience, for research and development in Freeze- and Vacuum-drying and associated problems.
(2) *Chemical Engineers*. (A.M.I. Chem.C. graduate or H.N.C. studying for further qualifications) for molecular distillation and allied High Vacuum chemical work.
(3) *Research Assistants*. (Degree or equivalent) for experimental and development work on plant connected with all aspects of High Vacuum metallurgy. Applicants should be interested in the development of equipment, rather than the metallurgical properties of the metals produced.
(4) *Junior Research Assistants*. (Advanced G.C.E. or Intermediate degree level) to assist in the above work and for work on High Vacuum instruments and pumping systems.

Successful applicants for the junior posts would be given opportunities for further study.

Permanent, pensionable position with

commencing salaries according to age and experience and commensurate with first-class man sought. Housing available. Applications with full details to the Personnel Officer.

ESSO PETROLEUM COMPANY LIMITED have many opportunities for Science and Engineering Graduates, resulting from further development and expansion at Fawley Refinery.

TECHNICAL DEPARTMENT

CAT. CRACKING PROCESS ENGINEER
HYDRODESULPHURISATION PROCESS ENGINEER
CHEMICAL TREATING PROCESS ENGINEER
UTILITIES PROCESS ENGINEER
LUBRICATION PROCESS ENGINEER
DISTILLATION PROCESS ENGINEER
EXPERIMENTAL CHEMIST

The above posts carry responsibility for studying and advising on process unit operations, planning, economic, and engineering design problems.

All these are regular progressive posts, with starting salaries ranging from the £600's for the younger newly qualified graduate to four-figure salaries for candidates with relevant industrial experience.

Continued expansion of the refinery gives excellent prospects for advancement. There are opportunities for technological and management training, where appropriate.

In addition there are a limited number of vacancies in the Technical Department for Assistants of Inter B.Sc. or H.N.C. standard. Applicants must have a good knowledge of Maths, an aptitude for calculations of a technical nature in order to assist graduate engineers in their work. Previous experience of Chemistry, Chemical Engineering, Physics or Engineering is essential.

Salaries are appropriate to age, qualifications and experience.

There is an excellent and comprehensive Pension Scheme; recreational activities of all kinds are available in a pleasant rural area bordering Southampton Water.

Please send post card for application form to Employee Relations Superintendent, Esso Petroleum Company Limited, Refinery Department (Dept. D), Fawley, Southampton.

SENIOR LABORATORY TECHNICIAN required at Paddington Technical College, Saltram Crescent, W.9, for work in the Chemistry, Physics and Biology laboratories. Salary scale—£444 to £566, and to £669 a year with specified qualifications. Particulars and application forms (returnable within 14 days) from the Secretary. (847.)

TECHNICAL WRITER. Standard Telephones and Cables Ltd., North Woolwich, London, E.16, require a Technical Writer to assist in production of Hand Books on various types of transmission equipment (Microwave, Coaxial Cable Telephone system etc.). Previous experience in this special type of writing in the Services or in Industry would be an advantage but not essential. Details of age, experience, qualifications, etc., to Personnel Manager.

APPOINTMENT WANTED

EXPERIENCED BIOLOGIST seeks change from Teaching. Box No. D.1534, Aldridge Press Ltd., 27 Chancery Lane, London, W.C.2.

LECTURES AND COURSES

FARADAY HOUSE ELECTRICAL ENGINEERING COLLEGE

A THREE-YEAR COURSE, commencing each term, in Electrical Engineering to qualify for Associate of Faraday House and Graduate of the Institution of Electrical Engineers, followed by one year's practical training in Industry to qualify for the Diploma of Faraday House. For Prospectus apply to Department "E", Faraday House Electrical Engineering College, 66 Southampton Row, London, W.C.1.

FAR AND NEAR—continued

No Sextant for Atlantic Crossing

When the new *Mayflower*, a copy of the Pilgrim Fathers' vessel, sets sail from Plymouth she will be navigated across the Atlantic by replicas of 17th-century instruments specially made by Kelvin Hughes Ltd. Three of these instruments now ready are a *cross-staff*, a forerunner of the sextant, made in pear-wood; a *traverse-board* on which was recorded at regular intervals the distance run and ship's course; two compasses (one a standby). There is no information about the navigational equipment of the original *Mayflower* but all the instruments being made are exact replicas of instruments known to be in use at that time and are copied from actual specimens on exhibition at the National Maritime Museum and at the Science Museum, South Kensington.

The instruments will be on view at Kelvin Hughes' main depot, Fenchurch Street, E.C.2., from the end of May.

Gas from Oil

The world's largest cyclic catalytic gas-making plant relying solely on oil is expected to be in production in the autumn of 1958. The Power Gas Corporation of Stockton-on-Tees is installing it for the South-Eastern Gas Board at the British Petroleum Company's oil refinery on the Isle of Grain, Kent. The final decisions to build have just been taken.

The installation will have a capacity of up to 20 million cubic feet of town gas per day.

Arsenic and Old Wallpaper

The Conservative Member for Arundel, Mr. Kerby, in a recent parliamentary question suggested that there was danger to life from "the volatilisation of the arsenic content of certain wallpapers". The Home Secretary is looking into the matter. He would welcome further information on the subject, he said to Mr. Kerby.

Printed and published in Great Britain by Jarrold & Sons Ltd., Norwich *Editorial Office: 244 High Holborn, W.C.1*

White trail

High over London, a lone jet fighter traces its path across the cloudless sky, and men and children stop for a moment to look. From his vantage point 40,000 feet above them, the pilot sees, through his canopy of ' Perspex ', the English Channel and the coastline of France curving away into the distance. For many years now, transparent ' Perspex ' has been used to make windows, canopies and blisters for aircraft, because it is light, easy to mould and unaffected by weather. This remarkable plastic has found countless uses on the ground, too, in the twenty-odd years since it was discovered by I.C.I. research workers. The street lamps and signs that add colour and sparkle to our great cities are made from it. Corrugated ' Perspex ' lets daylight into dark buildings. Surgeons and dentists use ' Perspex ' instruments, and dentures and artificial eyes are made from a different form of the same versatile material.

Thus, and in a thousand kindred ways, I.C.I.'s research and production are serving the Nation.

ICI